



PRACTICAL TREATISE  
ON  
THE BLEACHING OF LINEN AND  
COTTON YARN AND FABRICS

THE ABERDEEN UNIVERSITY PRESS LIMITED



PRACTICAL TREATISE  
ON  
The Bleaching  
OF  
Linen and Cotton Yarn and  
Fabrics

BY  
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## AUTHOR'S PREFACE.

IN the composition of this treatise I have been guided—

1. By a book published in England under the title *Hints to Bleachers ; or, Remarks on the System adopted in the North of Ireland for Bleaching Linen Fabrics.*

2. By the information which has been given me by men in the trade, works managers, foremen and workmen.

3. By the experience I have myself acquired as managing director of bleach works, and as a consulting engineer.

The work has been written from a practical standpoint : thus all bleaching operations are described with full details and many hints. The same remark applies to the descriptions of the plant and machinery in most general use in bleach works.

The methods quoted as examples have been adopted after many trials ; moreover, they have been sanctioned by use.

Special sections are devoted to the titration of “ salts of soda,” to chlorometry or the titration of decolourising chlorides, and to hydrotimetry or the titration of hard waters. The methods described can be performed by every intelligent foreman. The question of the caustification of carbonates of soda by lime, of the manufacture

of the "chlorides of soda," and of the production of decolourising chlorides by electricity are given after processes easily worked in bleach works.

I, therefore, believe that my work well fulfils the part of a practical guide for the bleacher, asked for by several societies of chemical industry, and that it is of such a nature as will assist the manager of the works in the performance of his duties.



## TRANSLATOR'S PREFACE.

M. TAILFER'S work differs in many respects from English treatises on the same subject. The aim and scope of the book are fully described in the Author's Preface. Nevertheless, it may be pointed out, as a special feature of the work, that the author, as a master of his craft, deals precisely with those essential features of detail on which success or failure so much depends, and which are so conspicuously and characteristically omitted from our English treatises.

The translator, in his endeavour to render M. Tailfer's work into idiomatic English, may not always have expressed himself in the language of the bleach works. He, however, trusts that the terms and expressions he has used, although here and there perhaps not strictly technical, are never unintelligible.

The translator of the standard French "Works on Dyeing"—those of Hellot, Macquer and Le Pileur d'Apligny—published in 1789, makes the following remarks, which may not at the present time have altogether lost their significance :—

"Whether our good neighbours, the French, be our natural enemies or not, certainly they are our most powerful rivals in commerce and manufactures ; in this sense they are our enemies ; let us not therefore, from pride or ill-humour, spurn their instructions—*fas est et ab hoste doceri.*"

The translator has retained the chemical terms of the author, some of which are now rather obsolete, *e.g.*, *chloride* of soda where hypochlorite is meant. For want of a suitable word, the term *sel de soude*, so often used by the author for a mixture of caustic and carbonated alkali, has been rendered literally throughout as *salt of soda*. But in these and other cases the intelligent reader will easily understand from the context the article or idea that is meant.

Much additional matter, not included in the original, has been furnished by the author to the publishers, which has been translated and included in the present edition. The work has, therefore, been practically brought up to date.

THE TRANSLATOR.

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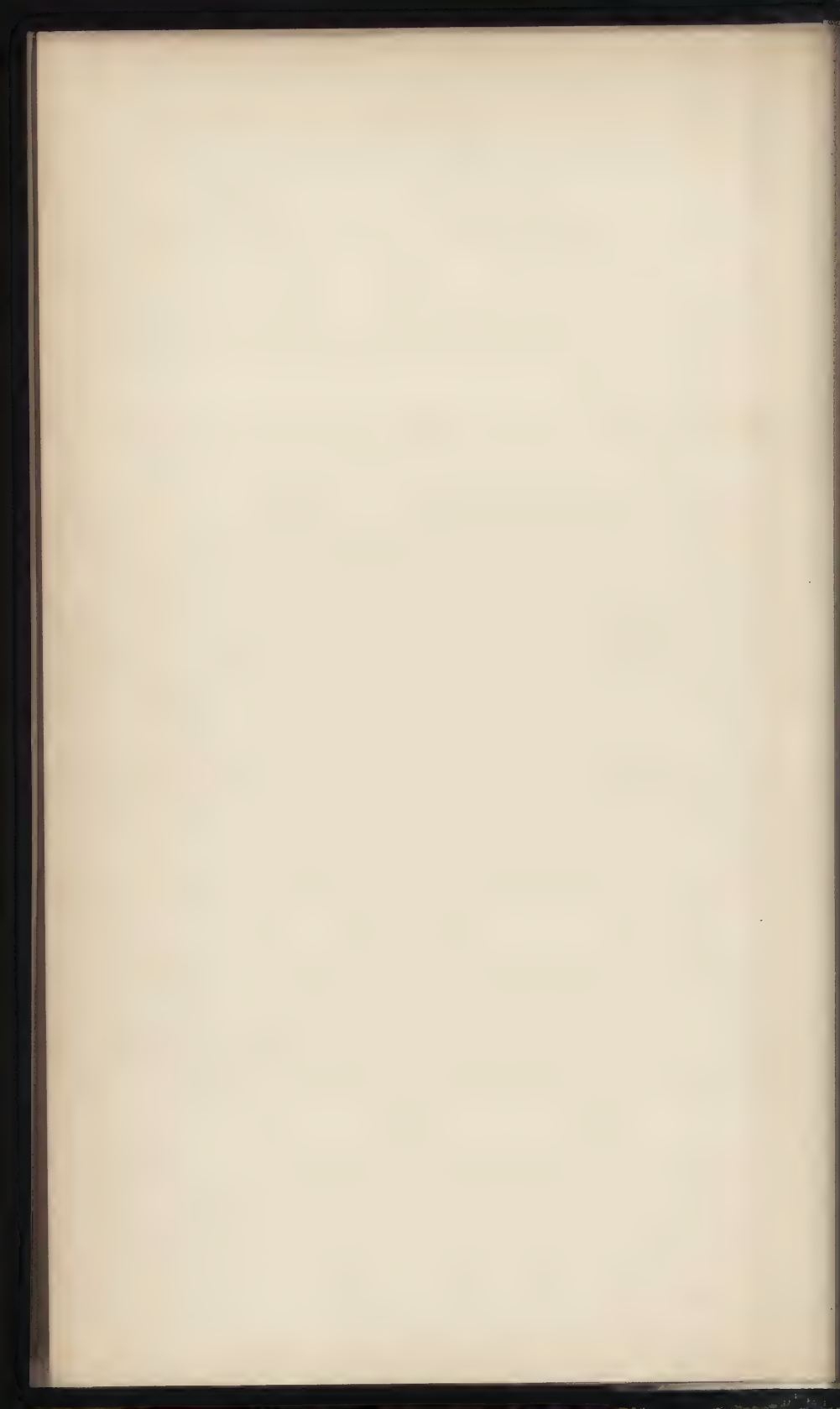
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## CHAPTER I.

### GENERAL CONSIDERATIONS ON BLEACHING.

*Object of Bleaching—General Indication of the Methods adopted and their Mode of Action—The Principal Points to which the Bleacher ought to give Attention.*

THE object of bleaching fabrics of vegetable origin is to decolourise the substances from which they have been produced. Flax, hemp and cotton are the materials most generally used ; jute and ramie are also used for very coarse fabrics. The fibres of these plants have a more or less deep yellow or black colour ; they must, therefore, be brought to the greatest possible degree of whiteness. In order to establish a rational theory of bleaching it is necessary to have a complete knowledge of the elements which enter into the composition of the fibres of these different plants, what the elements are that can be removed, or transformed, without injuring the soundness of the fabric, and what the chemical products are which bring about these modifications without attacking the parts of the fibres which it is desired to preserve intact. The study of these questions is very delicate, and little progress has yet been made, but there is no question but it will yet be the cause of much progress in the bleaching industry. At the present time, experience, observation and inference—more than anything else—have demonstrated the rules to be obeyed, or have indicated the series of treatments

which fabrics should be made to undergo in order to bleach them.

The alkalies, lime, soda and potash, are used to dissolve resinous and gummy substances. The soluble products thus obtained are expelled by washing.

During the time the fabrics are exposed on the bleaching green, air and light act on the tissues by oxidising the colouring matters and transforming them into colourless substances. This oxidation has also the effect of transforming the colouring matters into colourless substances much more easily dissolved by lyes, or more easily attackable by the "chemicks" which follow exposure on the green. The chlorine employed, whether in the state of a gas dissolved in water or in the state of hypochlorite, is another energetic oxidising agent. Its use, in the state of hypochlorite dissolved in water, is very general and convenient. But, speaking generally, substances which evolve oxygen on decomposition are decolourisers.

Acids ("sours") are used either to augment the energy of the decolourising principle, or to dissolve the salts encrusted in the tissue of the fabric, or, again, to render soluble the compounds resulting from the previous reactions, and thus enable them to be eliminated by washing.

Each of these different operations has an action peculiar to itself, and they ought to succeed each other in a certain order. They cannot produce their effect instantaneously, but they act in such a slow, gradual manner as will not attack the constituent part of the fibres. In fact, the fibres have, first of all, been twisted together in the spinning mill to make yarn, then this yarn has been woven to make cloth. It becomes, therefore, very difficult for chemical agents to reach the central fibres without producing an injurious effect. Their action is at first superficial, and the washing removes the first products which have been dissolved. The fabric is then submitted a second time to the action of the same agents; they now



penetrate more deeply, and the products thus formed are expelled by a second washing, and so on.

The operations vary according to the nature of the substances of which the fabric is composed, whether it has been spun with fine or coarse yarn, loosely or tightly spun, loosely or tightly woven. Cotton is easily bleached in a few operations; linen bleaches much more difficultly, and requires a large number of operations. It is also necessary to vary the operations with the country or source of origin of the textile materials—thus, Russian linens are more difficult to bleach than French or Belgian. Hemp is bleached in the same way as linen, likewise jute and ramie; but the fabrics made of the two latter do not take a decided enough white.

The art of the bleacher, therefore, consists in discerning and applying the operations suitable for each kind of fabric according to whatever stage of advancement it may be in in the bleaching process. The degree of concentration of the lyes, of the “chemicks” and “sours” ought therefore to be determined. If they be too strong, the soundness of the fabric suffers; if they be too weak, the fabrics must receive supplementary treatment: hence, there is loss of time, manual labour and chemicals, and the more the fabrics are handled, the more they risk being damaged. It is therefore necessary to work in such a manner that each operation may be carried out in the best possible conditions, and although that involves rather considerable care and attention, it will be seen that, making allowance for everything, there is great advantage in this method of procedure.

It is not at all necessary to have extensive chemical knowledge in order to be a good bleacher, but it is very advisable to have some knowledge of the chemical products in most general use, so as to be able to make a valuation of them when delivered by the drysalter. The bleacher ought also to

be able to titrate the lyes, the "chemicks" and "sours," so as to make them of a suitable degree of concentration.

The bleaching industry is not very complicated, but it requires great faculties of observation and much system and order.

It is necessary to examine the fabrics often so as to ascertain the effect produced by each operation, and, as these are numerous, to make a note of the different treatments each lot or batch of fabrics are receiving simultaneously. From the data thus obtained the work of the bleaching works may be regulated.

The strength of the lyes and the "chemicks" ought to be tested and controlled every day by the foremen, and from time to time by the manager of the works. None of the prescriptions indicated for each operation should be neglected, because an operation badly done, by deteriorating a large number of fabrics, is the cause of considerable loss.

## CHAPTER II.

### STEEPING.

*Reason for Steeping—Temperature of the Water—Duration of the Process—Different Methods—When Steeping may be Dispensed with—Steeping in Spent Lye.*

THE first operation in bleaching is drenching or steeping. The end in view is to get rid of the surface coating of grease, oil, dust and dirt, and of various substances with which the yarn gets impregnated before and during weaving.

The fabrics are allowed to steep in water heated to  $60^{\circ}$  C. ( $140^{\circ}$  F.) for about eighteen to twenty-four hours. The water must be hot enough to start the fermentation of the surface coating, render it soluble, and thus enable it to be eliminated in the washing; but on the other hand it must not be heated too highly, because it would then bake the surface coating, which would be more difficult to eliminate afterwards. Fabrics should not be allowed to steep too long, because prolonged fermentation would entirely destroy them. When the water commences to give off a bad smell it must be run off and renewed, if the fabrics are not to be washed immediately. One plan is to have a reservoir in which the water is heated beside the vat. The hot water is run in from the reservoir at the same time as the vat is being charged with the fabrics. This water is at first heated to between  $70^{\circ}$  and  $80^{\circ}$  C. ( $158^{\circ}$  to  $176^{\circ}$  F.), but it quickly descends to between  $50^{\circ}$  and  $60^{\circ}$  C. ( $122^{\circ}$  to  $140^{\circ}$  F.). It is not necessary to have a large reservoir to heat the water. A small reservoir is fixed at a higher level

than the steeping vat. Water and steam are led to the bottom of the reservoir. The flow of water and the quantity of steam are regulated in such a manner as to produce the temperature required, and the hot water is run in, in requisite proportion, on the fabrics as they are being laid in the vat.

A second plan is to run in a current of cold water as the fabrics are being placed in the vat, and then to heat the steeping vat and its contents by a steam pipe placed below its false bottom. The disadvantage is that the fabrics near the steam are overheated, and the others not sufficiently so.

A third plan consists in filling the vat with cold water and heating the water to  $75^{\circ}$  C. ( $167^{\circ}$  F.). The fabrics are then pressed into the liquid with a stout stick. The fabrics occupy a much larger space and a much smaller quantity can be placed in the vat.

Two hundred to 300 *kilogrammes* of fabrics can be put into a cubic *metre* (or say 450 to 675 lb. in the space occupied by 220 gallons of water).

The keirs used for boiling with alkaline lye may be used for steeping. If special vats be allocated for this purpose they may be made of mason work, with an internal coating of cement. They last indefinitely, but the lining of cement is eventually attacked on the surface. It becomes rough and uneven. In the case of fine textiles it is preferable to line the inside of the vats with wood. Wooden vats are very convenient: they can be shifted from one position to another.

In order to economise time and working expenses, steeping is dispensed with and the textiles are at once treated with lye. The author does not recommend doing away with the steeping, because soda, at a high temperature, does not dissolve the surface coating of the fibres very well, and it hinders the action of the lye.

Steeping may be dispensed with when a lime lye is used,



because lime energetically attacks the surface coating. The author is acquainted with bleach works where this method has been in practice for many years both for linen and cotton fabrics, and no defect has ever been seen in this method of working.

But in the case of fabrics woven with cream-coloured yarn it is prudent to commence operations by steeping. As a matter of fact cream-coloured yarn has not been very well washed after the chemick. Steeping, followed by washing, removes any remaining chlorine, and renders the performance of the subsequent operations safer.

Steeping ought always to be followed by washing.

Several bleachers, in order to have better results from the steeping, add a little soda crystals to the water, say 1 lb. of crystals to 100 lb. of textiles. Use is also made of spent lye, which is kept in reserve for steeping. The trials made by the author have demonstrated that the results obtained are not sensibly superior to those obtained with hot water.

## CHAPTER III.

### WASHING—ITS END AND IMPORTANCE.

ROLLER WASHING MACHINE.—*Description—Tension and Non-Tension Washing Machines—Speed—Dimensions of the Rollers—Distribution of the Water—Number of Spirals—Entrance and Exit of the Pieces—Duplex Roller Machine—Damage done by the Roller Washing Machine.*

WASH WHEEL (DASH WHEEL).—*Description—Practical Information—Damage, Precautions to take—Advantages and Disadvantages of this Method of Washing.*

STOCKS OR WASH MILL.—*Description and Hints—Management of Wash Mills—Advantages and Disadvantages of this Method of Washing.*

SQUEEZING.—*Its Utility—Draining—Centrifugal Hydro Extractor—Roller Squeezing Press.*

THE different bleaching operations, such as lye-boiling, chemicking, souring, ought always to be followed by washing. Too much special care cannot be taken in washing, for on it depends all the safety of the processes used. When the fabrics are deteriorated or become deficient in strength, it is more likely to be due to insufficient washing than to too strong lye-boils, chemicks, or sours.

Lye-boiling renders the resinous or gummy matter of the fabrics soluble; but a portion only of these substances is carried away by the lye-boil: the other portion, the removing of which is the object of washing, remains in the interior of the fabric.

Washing also removes the lye with which the fabrics are impregnated after each lye-boil, and that is a very important point, especially if the fabrics are afterwards to be exposed on the bleaching green. The action of air on soda lye, especially on caustic soda lye, has the effect of damaging the fabrics very quickly, in contact with the fibres.

The fabrics ought to be washed as they come out of the chemicks and the sours, because the chemicks and the sours continue to act upon them and deteriorate them rapidly. Washing ought to follow the chemicking and the souring very closely, and it is especially necessary to prevent the fabrics from drying in the interval.

The object of washing is to prevent the different chemicals employed in bleaching from coming together and reacting too violently—the one on the other—in contact with the fabrics. For example—after a lime-boil the fabrics are soured, and this sour is intended to remove the lime which has penetrated into the interior of the fibres of the fabric. But it is, first of all, necessary to wash the fabrics, as thoroughly as possible, between the lime-boil and the sour. If this be not done, the acid, coming in contact with a greater or less quantity of lime, reacts on it violently, and the resulting transformation of a considerable quantity of lime into chloride of calcium does not take place without injuring the textile fabrics.

Washing between the chemick and the sour is also necessary. If the fabrics be still impregnated with chemick when they are soured, the acid liberates chlorine very briskly, which reacts on the fabrics, and there is a risk of damaging the fabrics. This method is sometimes used to increase the energy of the chemick, but it must be done with great caution.

A description of the different washing machines will now be given, in which their advantages and disadvantages will be dwelt upon.

ROLLER WASHING MACHINE.<sup>1</sup>

*Description.*—This machine consists of two hard-wood cylinders, the one turning on the other. The lower cylinder is driven by a belt or gearing, and the upper cylinder turns round in the train of the lower one. Below these cylinders there is a trough of wood or cement filled with water which is constantly being renewed. The fabric, drawn by the rollers, descends into the trough to be washed, passes below a cross

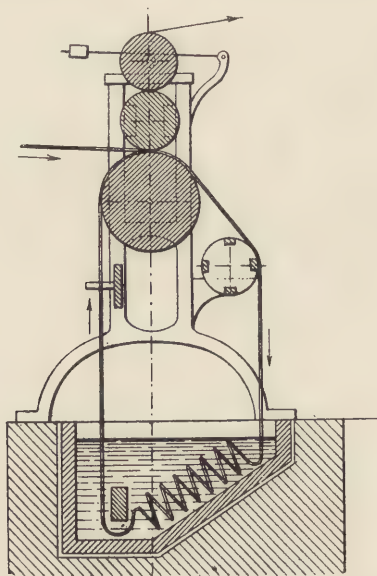


FIG. 1.—Non-Tension Roller Washing Machine.

piece or a roller fixed near the bottom, rises on the other side to pass a second time between the rollers and re-descends again into the trough, and so on a dozen of times.

The lengths circulate spirally. The machines are provided with various cross pieces to regulate their proper working and ensure thorough washing.

<sup>1</sup> See illustration (Section, Elevation and Plan) of Roller Washing Machine on page 62 as it is used for saturating fabrics with alkaline lye.



The upper roller is surmounted by two small cylinders, placed at its extremities. The object of the first is to stretch out the cloth as it enters, and that of the other is to squeeze it as it comes out of the machine. The pressure on the rollers may be increased by weights fixed to the end of levers, which press on their axis.

On the side where the fabrics descend, a reel, moving more rapidly in its circumference than the rollers, draws in the lengths, and hinders them from sticking to the rollers and from getting rolled round them, which is a frequent cause of damage. In the bottom of the cistern is a cross piece, underneath which the fabrics pass, and are thus forced to sink into the water. Sometimes the different lengths are separated by partitions, which hinder them from being entangled in the washing cistern. On the ascending side, the strands are guided by a ladder, which causes them to circulate spirally.

A pipe brings the water to the exit side. The discharge pipe is on the entrance side. The washing is therefore methodical.

It is unnecessary to enter into the details of the construction of these very simple machines. The reasons which have led to different modifications will alone be given.

*Tension and Non-Tension Roller Washing Machine.*—In the tension roller washing machine all the pieces are stretched. In the bottom of the washbeck is a roller, which turns on its own axis by the movement imparted to it by the fabric. This plan is adopted in roller washing machines of high velocity (the pieces revolving at the rate of 10,000 *metres* ( $6\frac{1}{4}$  miles) an hour), in which case there would be danger of entanglements if the pieces were not stretched.

This arrangement is also used in the case of coarse sheetings, which are very stiff, and which would not sink into the water if they were not stretched.

In the non-tension roller washing machine 3 or 4 *metres*

(10 to 13 feet) of fabric are left slack, which dip in the water and work about therein. The water, in this way, penetrates better throughout the fabric. To use this system, the fabrics must not be too stiff or too bulky, and the speed should not exceed more than 5,000 to 6,000 *metres* (3 to 4 miles) an hour.

*Speed—Size of the Rollers.*—The speed depends on the nature of the pieces to be washed. In certain tension machines a speed is given to the pieces of 8,000 to 10,000 *metres* (5 to 6 miles) an hour. To work at this speed the fabrics require to be light and spongy. The workmen who look after the roller washing machine ought to be very careful, for the slightest tear is the cause of considerable damage. When very large pieces are being treated, the speed of the pieces is reduced to between 1,500 and 2,000 *metres* (1 and 1 $\frac{1}{4}$  mile) per hour.

In the non-tension machines a good speed to adopt, in the washing of light fabrics, is 5,000 to 6,000 *metres* (3 to 4 miles) per hour. This speed is reduced when washing heavier fabrics.

The lower driving roller ought to be big enough to present a large contact surface to the fabrics, and to draw them in without slipping. A diameter of 60 *centimetres* (2 feet) is a very suitable one. When the roller is worn it is turned over, but when the diameter gets less than 45 to 50 *centimetres* (18 to 20 inches) the roller is of no further use, or it must be refitted with wooden staves to bring it to its primitive diameter. The rollers are sometimes encircled with hemp or aloes rope. It is the rope which wears; the diameter of the roller remains constant.

The upper roller serves to press the pieces on the lower roller, so as to facilitate their being drawn in; its diameter is less than that of the lower roller, varying from 30 to 40 *centimetres* (12 to 16 inches). At the two ends of the roller washing machine, and fixed to the building, is a system of screws

or levers by which the upper roller may be rapidly raised so as to withdraw the goods, in case of accident, or to regulate the portions floating unstretched in the basin. When the pieces pass always over the same part of the rollers they eventually run into grooves, and the drawing-in power, due to the pressure of the upper roller, is diminished. It is advantageous to vary from time to time the position of the ladder which determines the direction of the spirals, so as to use up the rolls in a uniform manner.

The wood which suits best for rollers is beech or plane tree. It is necessary to use wood which has been felled a long time previously, and which has been preserved under water.

*Distribution of Water—Quantity to Furnish.*—It is rational for the water inlet pipe to be on the side of the trough where the fabrics come out, and for the exit pipe to be on the side where they enter. To ensure perfect washing it is necessary that the water in which the pieces dip, for the last time, before their final exit should be almost pure. By examining the water, on the exit side, a few times, its state of purity is ascertained, and the outlet and inflow of water regulated accordingly. Generally, 700 to 1,000 *litres* (150 to 220 gallons) of water are used up per minute.

In certain machines the water is not simply run into the troughs: a horizontal perforated pipe distributes the water, in a shower, on the fabrics; at the same time, a drum, studded with wooden rods, gives them a to and fro motion which facilitates the penetration of the water. This system yields very good results.

In order to see whether the pieces are well washed, a little of the water with which they are impregnated as they come from the wash is squeezed out and tested with litmus paper as to whether it is acid or alkaline. If either, it is necessary to increase the water or to resort to fresh washing.

*Number of Spirals.*—This number should not be less than

eight or ten to secure good washing, and requires rollers of 3 to  $3\frac{1}{2}$  metres (say 9 ft. 9 in. to 11 ft. 4 in.) long. If, working in this way, the washing is still imperfect, the pieces are passed through the roller washing machine a second time, or a double roller washing machine is used.

*Entrance and Exit of the Pieces.*—The entrance of the pieces is guided by a porcelain "pot eye". Sometimes, alongside the entrance, the rollers are surmounted by a small compressing roller, which renders the traction more energetic. The fabrics are brought, in waggons, to the front of the washing machine, or they may very well be wound directly from the lye-boiling keirs, chemicking or souring cisterns. When these machines are at a long distance from the washing machine the pieces are supported and guided by wooden rollers, turning freely round their axis to diminish friction. These rollers are vertical or horizontal according to the direction to be given to the pieces. At the exit side it is very convenient to have a compressing roller to squeeze the pieces.

A workman collects the pieces and makes them into bundles, or piles them in folds in the waggons. Mather and Platt of Manchester make a folder which piles the pieces mechanically on the waggons.

The fabrics may also be piled directly into the lye-boiling keir, the chemicking or souring cisterns, by means of a traction roller which delivers them into the receivers. This roller ought to be simple and draw the fabrics by adherence, and not by the friction of two rollers the one upon the other. Owing to the difficulty of making the speed of the washing machines and the rollers agree, there would inevitably be jerks injurious to the fabrics.

The pieces are joined together, the one after the other, by laces sewn to their ends, or by pieces of twine attached to their corners. Sometimes fine pieces are tied together by their



ends. The knot must be tied with great care, and it must not be too big, because there would be a risk of its cutting the fabric as it passed through the rollers.

*Duplex Roller Washing Machine.*—This washing machine is formed by two machines coupled together, in which the lower rolls are connected by gearing. These two rolls make exactly the same number of turns per minute, and are of equal diameter, the speeds on their circumference being rigorously identical. There is therefore no risk of jerking. This arrangement has the advantage of giving a double wash without extra cost of labour or loss of time. It is, moreover, used for treating the fabrics with lye, and to wash them immediately afterwards; the first trough contains the lye, and the second the running water to wash the fabrics.

*Damage due to Washing Machines.*—In order to avoid damage, care must be taken to see that the rollers are in good condition, that they have no asperities or knots, that foreign substances, such as nails, bits of iron, etc., do not get incrustated or imbedded therein, and to guard against this they should be frequently inspected.

A frequent cause of damage arises from the fabrics as they come from the bleaching green containing pebbles in their folds. If they are washed in that condition by the roller washing machine, the pebbles in passing between the rollers make holes in the fabrics.

This danger is avoided by lifting off the upper roller. If the washing machine be working under tension, the adherence suffices to draw the pieces. In non-tension machines it is difficult to pass the pieces under the upper roller. To increase the adherence, a canting roller is used, only the ends of which are turned. The turned parts are surmounted by small rollers, the pressure of which draws the pieces, but this pressure ought to be slight, so as not to damage the fabrics if there be small pebbles in the folds. The best thing to do, however, is to

take care that the bleaching greens are well kept, and that the fabrics run no risk of bringing pebbles or other hard substances in their train.

When the machines exert too great a tension on the cloth, they may break the selvage, or deform the designs of the fabric. If the pieces be light, it is preferable to use a non-tension machine.

#### WASH WHEEL.

*Description* (see Fig. 2).—This machine consists of a wooden drum-shaped cylinder, divided in the interior into

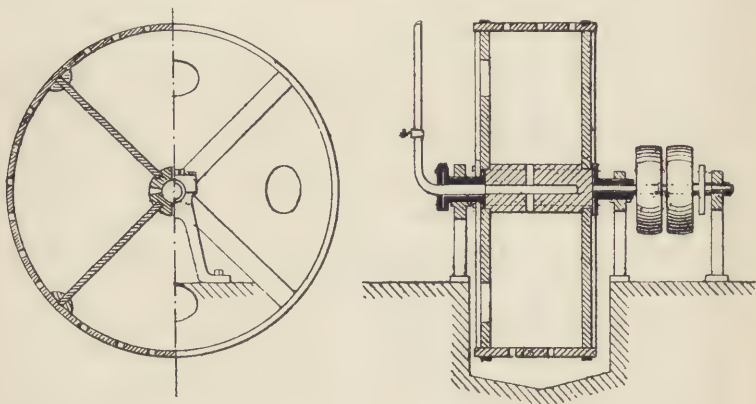


FIG. 2.—Wash Wheel.

four compartments, and turning on its own axis. This cruciform axis forms a passage for the water, which, filling the compartment, issues from the circumference, in which holes are bored for the purpose. The fabrics are introduced into the compartments; during the time the wheel is revolving they are projected against the sides of the partition and the circumference; the water with which they are impregnated is expelled, by the shock, time after time, and it is this effect which produces the washing.

The wheel is supported on its axis by spokes. The axis carries, behind the wheel, pulleys or gearing by means of which it is driven. A clutch, fixed on to the shaft, is used to stop the wheel, which would continue to turn on its axis for some time in consequence of its acquired velocity.

The nave of the wheel is made of wood, and is prolonged to the outside by iron arms, which are bound together by four bolts passing through the wooden nave.

On the front face of each compartment is an elliptical aperture for introducing and taking out the fabrics. They are deposited on a wooden or stone platform, built for this purpose, in front of the wash wheels.

*Practical Data.*—The following figures refer to a wheel having the undernoted dimensions: Diameter, 2 metres ( $6\frac{1}{2}$  feet); depth, 60 centimetres (2 feet). The number of turns per minute, 20 to 22. Diameter of pipe which brings the water, 40 millimetres (1.57 inch). The flow per minute, 225 litres (say 50 gallons). The weight of the fabric put into each compartment, about 10 to 12 kilogrammes (23 to 28 lb.).

The length of time of washing varies with the operation which has gone before. The following times, fixed by experience, may serve as standards to go by for light fabrics:—

FABRICS COMING FROM—							DURATION OF WASHING.	
Steeping	-	-	-	-	-	-	10	minutes.
Lime-boiling	-	-	-	-	-	-	15 to 20	"
Sour after lime (Grey Sour)	-	-	-	-	-	-	15 to 20	"
Lye-boiling	-	-	-	-	-	-	12	"
Chemick	-	-	-	-	-	-	12	"
Sour after chemick (White Sour)	-	-	-	-	-	-	15	"
Last washing before finishing	-	-	-	-	-	-	20	"

*Damage—Precautions to Take.*—This machine causes little damage; the fine pieces, occupying a small volume, are washed in it. The workman, in taking out the fabrics, should not pull them too roughly for fear of tearing them. When the

wheel is at work there is a risk of the pieces coming out by the aperture and rolling round the shaft. The aperture therefore should not be too big, a length of 35 *centimetres* for the long axis and 25 *centimetres* for the small axis (14 inches and 10 inches) is very suitable. The boards should be well adjusted and tight. If during working they get dislocated,

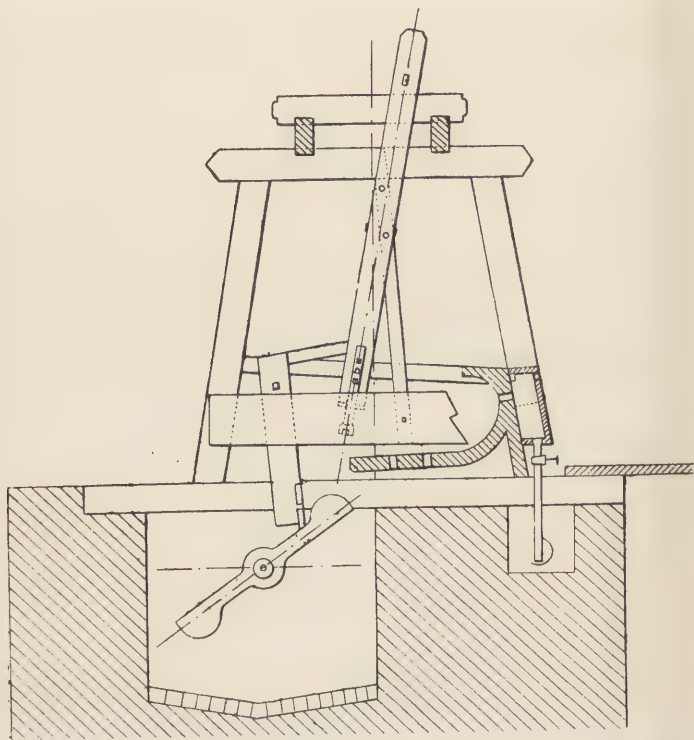


FIG. 3.—Stocks or Wash Mill.

receding from and approaching each other, they pinch the fabrics and tear them.

Care must be taken that no asperities are produced inside the compartments, *e.g.*, protruding nails, cracks in the timber, etc. When the water is calcareous a very hard coating of lime is deposited on the surface of the sides and shales off; this



calcareous deposit must be removed, from time to time, when it gets too thick.

*Advantages and Disadvantages of this Method of Washing.*—Washing by the wash wheel is a very good method, because it does not wear the fabrics. During the process the pieces are projected against the sides, and the water which penetrates them is expressed with the dirt which they contain. If hard bodies, such as pebbles, pieces of wood, etc., have got entangled in the fabrics, there is less chance of damaging them than with the washing machines or wash mills. The disadvantage of this method of washing is that it costs much more for labour, and takes up much time. As only 10 to 12 kilogrammes (22 to 28 lb.) can be put into each compartment, it is only suitable for light fabrics, such as handkerchiefs, embroidery, ribbons and short lengths. To wash coarse sheets, they must be divided into small sections.

#### STOCKS OR WASH MILL.

The illustration, Fig. 3, shows the arrangement of a set of stocks or wash mill. In these a piece of wood, in the form of a hammer, is suspended from an axis, around which it oscillates. This hammer carries a handle in its lower part, and a cam, striking against it, raises it to a certain height and then lets it fall back. The fabrics to be washed are placed in a wooden drum of an oval form, into which the water runs. The water penetrates into the fabrics as the hammer or stock is raised, and is squeezed out by the concussion of its descent.

The drums separated by partitions form a series of compartments, each having a width of 1.40 metre (say  $4\frac{1}{2}$  feet). In each of these there are two stocks, having a width of 65 centimetres (2 feet), and the cams are arranged in such a manner that each stock strikes the fabrics alternately.

Whilst the hammer compresses the fabrics, it, at the same time, imparts to them a movement of rotation round themselves. During the time the hammer is again raised up the bundles of fabrics open, and are again thoroughly soaked with water.

The water runs in through a pipe placed in front of the drum. Before being run in, it passes through a copper wire gauze, which stops small pebbles and other hard bodies. The illustration, on the scale of 2 *centimetres* per *metre*; or 1 to 50, serves to show the principal dimensions of the machine. Each compartment has a width of 1.40 *metre* (say 4½ feet). Each hammer or stock has a width of 65 *centimetres* (say 2 feet); there are two in each compartment. They each strike thirty blows per minute; say double the number of the turns of the shaft.

The quantity of water run into each compartment is 300 to 350 *litres* (say 65 to 90 gallons) per minute. The weight of the fabrics is 70 *kilogrammes* (154 lb.).

The length of time occupied in washing is variable, according to the nature of the fabrics and the preceding operation.

FABRICS COMING FROM—							DURATION OF WASHING.
Steeping	-	-	-	-	-	-	30 minutes.
Lime-boiling	-	-	-	-	-	-	40 „
Sour after lime (Grey Sour)	-	-	-	-	-	-	35 „
Soda lye-boil	-	-	-	-	-	-	30 „
Chemick	-	-	-	-	-	-	30 „
Sour after chemick (White Sour)	-	-	-	-	-	-	35 „
Last washing before finishing	-	-	-	-	-	-	45 „

*Management and Working of Wash Mills.*—The drums must not be filled too full; room must be left for the water to penetrate through and around the fabrics. Especial care must be taken that the fabrics, by turning on themselves, do not form a kind of ball, the interior of which is very hard. It is sometimes the fault of the machine, but more often it

is because the machine has been filled too full with fabrics. The washing is defective, because the water does not penetrate into the interior of this mass.

As soon as this is seen, they are separated by a push from a stick; if this does not do, the stocks are stopped, and the pieces divided by hand. The stocks and the interior of the machine must be smooth. The distance between the stocks must be regulated by partitions, etc., so that the pieces are not pinched; 2 to 3 *centimetres* (say  $\frac{3}{4}$  to  $1\frac{1}{8}$  inch) answers very well.

*Advantages and Disadvantages of this Method of Washing.*—

In this method of washing the water penetrates the fabrics, and is pressed out by the compression of the stocks. It differs, therefore, from washing by the roller washing machine by the fact that, in the latter, the water glides over the surface of the fabrics. As the fabrics remain at least half an hour in the wash mills, and the stocks strike thirty blows per minute, they are compressed 900 times ( $30 \text{ blows} \times 30 \text{ minutes} = 900$ ). The work is analogous to that of the washerwomen, who plunge their linen in water and compress it by striking it with a wooden post.

If fine fabrics are being washed, such as muslins, cambrics, Irish linen, the water easily penetrates all through. This is an excellent method of washing, and it ought to be preferred to wash wheels or washing machines. It is not adapted for thick sheeting, and is difficult to handle unless the fabric be divided into small sections.

This method of washing requires a great deal of motive power, labour and time, and consequently costs dear.

*Washing by Hand.*—Washing by hand is resorted to in the case of very fine fabrics, which one would not dare to risk in the machines. A convenient way of working is to throw the fabrics into a basin, stretch them out to their full length, hold

them by the hand at one end, then draw them back towards the operator eight or ten times with the other hand.

The fabrics may also be put under a water pipe with a rose mouthpiece which rains the water over them. They are turned from time to time, so that the water may penetrate right through them.

*Washing in the Keir.*—When the boiling is finished, the lye is either run off or recuperated in a special tank, to be used over again. It is then advantageous to run first hot water on the fabrics, which removes better the lye and the substances it has dissolved; then cold water is run on them.

If there be no hot water in stock, cold water is run on and heated by the steam coil in the same way as the lye, circulation is established, and the wash water run off; the same operation is recommenced again with cold water until the wash water runs away clear.

Care must be taken that the exit tap is fixed at the lowest point of the bottom of the keir, and that it is large enough to evacuate all the deposits. If not, dirt will accumulate below the false bottom, the circulation of the water will bring it on to the top of the fabrics, and it (the circulation) becomes more injurious than useful. If circulation be not performed, water is run in on to the top part of the keir and run out from the bottom. In this case it is advisable not to open the exit tap until the keir is filled with water. By proceeding otherwise there would be the risk of the water running through those portions of the fabrics where it encountered the least resistance, and leaving the other parts unwashed.

#### SQUEEZING AND WRINGING.

*Its utility.*—The end of this operation is to express the water which the fabrics retain after washing. Its utility depends on the fact that the water retained by the fabrics diminishes the energy of the action of the bleaching agents,



preventing their intimate contact with the textile fabrics, and diluting beyond all measure the lyes, the chemicks and the sours. If no squeezing be done after washing, the strength of the lyes, the chemicks and the sours which follow must be increased, and in spite of that the result is not so good. The squeezing before drying removes a portion of the water, which would take very long and be very costly to evaporate.

*Drainage.*—The most simple method of expressing water is to pile up the fabrics after washing, and let them drain for a longer or shorter period of time. In this case the fabrics still retain a considerable quantity of water.

*Wringing.*—Another method is to hand-wring the fabrics; the water is well expressed. This method is not practicable with long pieces or large quantities; it should only be used for small lots or very costly fabrics which one would fear to risk in the machine.

*Centrifugal Hydro Extractor.*—This machine, as shown in Fig. 4, consists of a cylindrical cage, the side of which consists of a perforated copper plate or of copper wire gauze. This cage is mounted on a vertical shaft which imparts to it a rotatory movement. The fabrics to be operated on are placed in the cage, the centrifugal force presses them strongly against the side of the basket and the water is projected outside. The water is stopped by a cast-iron cover which has two orifices in its lower part for the water to run off. The rotatory movement is communicated to the shaft by friction cones, and suitable arrangements are adopted for the good working of the machine (clutches, lubricators, etc.).

These machines are very much to be recommended because they do not wear the fabrics, and they express the water very well, provided always that they turn at great velocity. They require a great deal of force to drive and the attendant labour

is considerable. Pieces should not be voluminous, as it is difficult to get them into the cage.

*Squeezing Rollers.*—When the fabrics are in rolls or coils it is more convenient, and above all more economical, to pass them through squeezing-rollers. The lower roller is driven by a belt and pulley, and the upper roller is weighted so as to act as a compressor. A “pot eye” guides the entrance

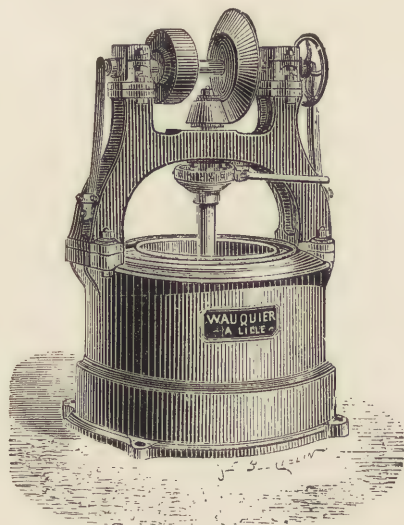


FIG. 4.—Centrifugal Hydro Extractor.

of the pieces; it is given a to and fro motion, so that the pieces do not always pass over the same place, which would form a groove in the rollers. Sometimes the rollers are covered with hemp or aloes rope; the rope is then worn and not the rollers, and the pressure is stronger.

It is advantageous to place this machine next to the roller washing machines. The pieces pass directly from the washing machine to the squeezer, and there is economy in labour.

## CHAPTER IV.

### LYE-BOILING.

LYE-BOILING WITH MILK OF LIME.—*Choice of Lime—Slaking the Lime—Keir for Lime-boiling—Placing Fabrics in Keir—Quantity of Lime to use—Duration of the Boiling Process—Washing—Important Observation.*

LYE-BOILING WITH SODA LYES.—*Necessary Conditions for Good Boiling.*

DESCRIPTION OF LYE-BOILING KEIRS.—*Keirs heated by Naked Fire—Wooden Keirs heated by Steam, with Circulation of the Lye—Cast-iron and Wrought-iron Keirs—Pressure Keirs and Circulation of Lye by Centrifugal Pumps—Sir James Farmer's (Manchester) Keir.*

OPERATIONS OF LYE-BOILING.—*Arrangement of the Fabrics in the Keirs—Saturation—Washing in the Keirs—Salts used in the Lyes—Lessive Phénix (Washing Powder)—Alkaline Sulphides—Concentration of Lyes—Testing Strength by the Hydrometer—Proportion between the Weight of Soda and the Weight of the Fabrics—Preparing a Lye—Recuperation—Temperature of the Lyes—Length of the Boiling Process.*

### MILK OF LIME LYES.

THE use of lime for bleaching fabrics is of very ancient date. Xenophon narrates that a ship loaded with linen fabrics and with lime for the purpose of bleaching them perished within sight of Marseilles, because a leak was struck in the bunker

where the lime was stowed. In the Middle Ages the rules of the bleaching trade corporations forbade the use of lime. Even now many bleachers will not use it, for fear of injury or impoverishing the fabrics.

However that may be, the use of lime may be regarded as attended with no danger if suitable precautions be taken. The process is cheap on account of the low price of lime.

The fabrics thus treated preserve their white colour better in the shop, and have less tendency to become yellowish.

*Choice of Lime.*—A fat lime is to be preferred containing no iron and as white as possible. It is better to have freshly burnt lime, stored out of contact with the air until the moment it is to be used. Some like to have lump quicklime, which they slake at the moment it is to be used; others find the use of powdered lime more convenient. We see no difficulty in using lime under either of these two forms; what is important is to take care that it does not carbonate in contact with the air.

*Diffusing the Lime in Water.*—A special sheet-iron tank should be provided for diffusing the lime through water. For this purpose the tank is filled with water, and a cage fitted with a sieve is suspended in the interior. The lime is run into this cage and stirred with a piece of wood so as to reduce it to paste, and thus enable it to pass through the gauze of the sieve. All the stones and other impurities remain in the cage and sieve. By passing the lime through the sieve, the meshes of which should not be more than 2 square *millimetres*, we may be certain that no unslaked particles remain which would burn the fabrics if they came in contact with them in the state of quicklime.

If the lime be allowed to stand a certain time before use it deposits at the bottom. Care must therefore be taken to stir the tank well up before sending the milk of lime on to the lime-boiling keir.



The tank in which the lime is diffused through water is generally placed in the interior of the bleach works, and in proximity to the fabrics. When the quicklime is being carried about, and when it is being thrown into the cage to be slaked and diffused, great care must be taken to guard against lime dust falling on the fabrics in proximity, for it would seriously injure them.

DENSITY OF MILK OF LIME OF VARIOUS STRENGTHS.

Degrees Baumé.	Densities.	CaO in 100 lb.	CaO in 10 gals.	Degrees Baumé.	Densities.	CaO in 100 lb.	CaO in 10 gals.
10	1·074	10·6	13·3	22	1·180	16·5	24·0
12	1·091	11·6	15·2	24	1·199	17·2	25·3
14	1·107	12·7	17·0	26	1·220	17·8	26·3
16	1·125	13·7	18·9	28	1·241	18·3	27·0
18	1·142	14·7	20·7	30	1·262	18·7	27·7
20	1·161	15·7	22·4				

To obviate this inconvenience the lime may be slaked in a cistern outside the bleach works proper, a paste being thus obtained which may be carried about without danger.

*Keirs for Lime-boiling.*—These vessels may be of wood, cast iron, or iron plate. Wooden vats are now but seldom made. Cast-iron vats last the longest, but they are dearer than iron-plate ones. The latter do not keep in the heat so well, but they may be lined inside with wooden staves, which at the same time prevent the fabrics from coming in contact with the iron. Rust is to be feared when the vat is new, but in the long run the iron becomes covered with a coat of lime, which preserves it against further oxidation.

It is very important that these keirs should be provided with a lid, even if it only be a wooden one simply placed on the vat, because a great loss of heat is thus prevented.

Inside the keir is a pipe for the circulation of the lye, of

diameter 0·10 *metre* (say 4 inches); it must be large enough so as not to become choked up by calcareous deposits. The steam, acting after the principle of Giffard's injector, causes the lye to circulate at the same time that it is maintaining the heat. A conical hood fixed above the pipe causes the lye to spread in a fan-shaped form. It stands to reason that the pipe should be placed in the centre of the keir, so that the lye may spread equally on all sides. Nevertheless, should the keir be small, the pipe is placed at the side, so as not to interfere with the proper laying down or piling of the fabrics in the keir.

*The Piling of the Fabrics in the Keir.*—Lime has some difficulty in penetrating through the fabrics; the most suitable means must, therefore, be taken to facilitate this penetration.

If the fabrics be laid in bundles, the cord is first slackened. The bundles are then placed in an upright position. When the first tier has been laid the water and milk of lime are run in, and the fabrics are tramped on so as to well impregnate them. Then a second tier is laid, and the same operation gone through. The keir filled, it is curbed or lashed so that the fabrics cannot rise up. The lashing generally consists in placing above the fabrics a thick rope net fixed on a circle, the whole supported by several cross pieces. Planks may also be used, supported by cross pieces.

Care must be taken to prevent the fabrics rising out of the liquid, and being thus exposed to the air or to steam. When the fabrics are laid in a band it is advisable to first of all impregnate them with lime, by causing them to pass, by the aid of propelling rollers, through a tank containing milk of lime and water. A man, with the help of a stick, arranges the folds regularly in the vat. If it be found too complicated to pass the pieces through a saturation tank, the work is so arranged that they fall into the vat at the same time as the milk of lime is being delivered, and that

the man who arranges them stamps on them with his feet in such a manner that they are well impregnated. This latter method is equally good, but it does not allow of so many

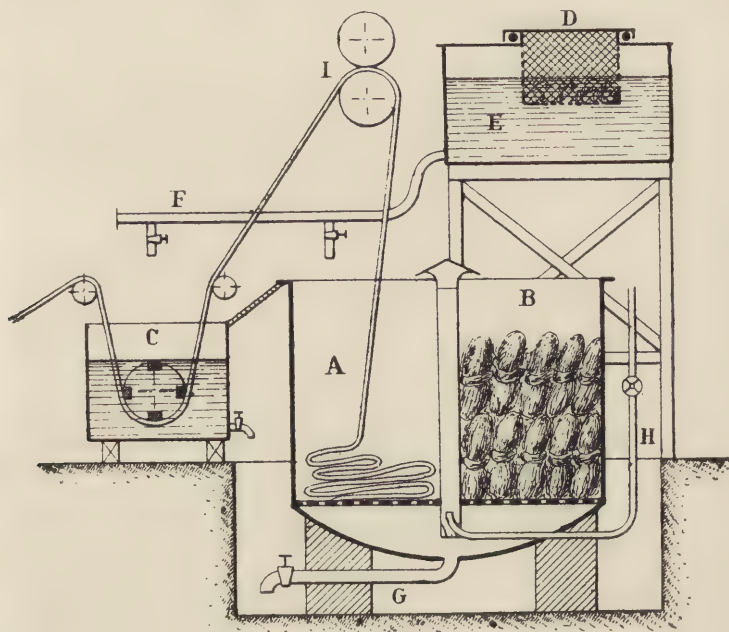


FIG. 5.—Lime-boiling Keir.

- A Piling in bands.
- B Piling in bundles.
- C Saturating vat.
- D Cage for sifting the lime.
- E Tank for preparing milk of lime.
- F Conduit for distributing milk of lime.
- G Discharge pipe.
- H Steam pipe.
- I Rollers.

pieces being laid in the keir. Fig. 5 shows the different methods of laying the pieces in the vat.

*Quantity of Lime to Use.*—The quantity of lime to use varies from 3 to 12 per cent. of lime on the weight of the

tissue. The quantity to use is indicated in the different examples of treatment. The bleacher will himself determine this quantity according to the degree of whiteness which he desires to obtain, and according as he has greater or less fear of injuring the fabrics.

*Duration of the Boiling Process.*—This will vary from eight to ten hours, and during this time care must be taken that the lye is kept in continual circulation. If the vat be a closed one, by which the temperature can be brought to  $110^{\circ}$  C. ( $230^{\circ}$  F.), the duration of the boiling can be shortened a little, but if the boiling be carried on under the normal atmospheric pressure the boiling should never last less than eight to ten hours.

*Washing.*—When the boiling is finished the lime water is run off. It is a good practice to run cold water on the fabrics so as to give them a first wash in the keirs, which takes away a portion of the lime. If it be necessary to leave the fabrics for some time before washing them, the keir must be filled with water so as to prevent the fabrics from drying whilst impregnated with lime.

*Important Observation.*—Soda lyes must not be made in the tank in which the lime is slaked and diffused, nor will it do to make use of lime keirs for boiling with soda lye, at least not without having washed them very clean. The remaining lime would transform the carbonate of soda into caustic soda, and the bleacher would obtain a much stronger lye than that which he counted on using.

#### LYE-BOILING WITH SODA LYES.

We have given separate instructions in regard to lime lyes because they are applied under quite different conditions from soda lyes.

We are about to describe different kinds of lye-boiling keirs and different methods of working with lyes, but to



obtain from the lye the best possible result care must be taken to realise the following conditions.

*Conditions necessary for Good Boiling :—*

1. The fabrics ought to be piled in the keir and the lye ought to circulate in such a manner that the fabrics are impregnated with it throughout their whole mass, otherwise spots will be produced where the dirty lye has lain, or unequal bleaching will be produced where it has not penetrated.

2. The steam pipes for heating the lye ought to be placed below the false bottom of the keir ; they are arranged in the form of a cross or a coil, and are generally pierced with holes to heat the lye by mixture and not by surface contact. This method of heating, by mixing, is more economical, but the steam in condensing dilutes the lye. Care must be taken that the steam pipes do not come in contact with the fabrics, or they would burn them. When the circulation of the lye is effected by the steam injector, and not by a centrifugal pump, and when the ascending column of lye is in the interior of the keir, it is prudent to surround this column by wooden staves so that the fabrics may run no risk of being burnt in contact with it.

3. During the whole of the boiling care must be taken to see that the fabrics are always immersed in the lye, and that the steam in swelling up the surface folds does not cause them to rise out of the lye ; this result is obtained by well lashing or curbing the fabrics ; it is well to keep them so with a net.

4. Finally, when the fabrics are taken out of the vat care must be taken that they do not dry impregnated with the lye, above all, with caustic soda lye, because they would be seriously deteriorated.

## DESCRIPTION OF SOME KEIRS FOR LYE-BOILING.

*Keir in which the Lye is heated with naked fire.*—Formerly, before steam pans<sup>1</sup> became general, the lye was heated by making a fire under the keir, and a hollow column placed at the side or in the centre allowed the lye brought up by the pressure of the steam to fall back on the top of the fabrics, and a continual circulation of the lye was kept up in this manner. When the keirs were of wood the lye was heated in a cast-iron vessel built over a furnace; the lye ran from the vat into the cauldron, from which it was taken back with a lye pot, to be again poured into the top of the vat containing the fabrics.

This is the method still used in the country to wash household linen. The lye is extracted from wood ashes, the water dissolving the carbonate of potash which they contain; the ashes are put into the bottom of the vat, with twigs of trees or pebbles to prevent them settling at the bottom and stopping the circulation, a sheet of gauze preventing the mud from mingling with the lye.

*Wooden Keir heated by steam, with Circulation of the Lye.*—Wooden keirs are still used in many bleach works. They are made of pine, the staves are supported by iron hoops, the pipe in which the lye circulates is placed either outside or inside, and the circulation is produced by an injector which heats the lye at the same time. These keirs keep the heat well, especially if they are furnished with a wooden lid. The temperature does not exceed 90° C. (194° F.), because the circulation is bound to be intermittent; in fact, if the steam is allowed to continually pass through the injector, it comes to pass that steam alone issues from the circulation pipe, and does not bring up the lye when its temperature is too high.

<sup>1</sup> The term "*pan*," except in obvious cases, is used throughout this book synonymously with "*keir*".—TR.

Steam must then be shut off, and the whole allowed to cool before turning it on to cause the lye to circulate again. It is of advantage to have near the keir a tank for saturating the fabrics with lye, and a tank for making the lye itself.

The false bottom of the keir is made of wooden laths nailed to grooved cross pieces so that the lye may be drawn from all parts of the false bottom. The heads of the nails should be well driven home, and care must be taken that they do not pass right through, because they would tear the fabrics. Wooden pegs may replace the nails with advantage. In lieu of a false bottom, the bottom of the keir is lined with a layer of pebbles or prunings of trees.

*Cast or Wrought Iron Keirs.*—Wooden keirs have been replaced by cast or wrought iron keirs. These keirs generally have lids, and are substantial enough to resist a pressure of two to three atmospheres. The working pressure should not exceed one and a half atmosphere.

This plan affords two advantages. The keir being closed, there is less loss of heat; by increasing the pressure the temperature of the lye is elevated, and its action becomes more energetic.

In Fig. 6 there is given an illustration of a cast-iron keir with lid.

Cast-iron keirs are heavier and dearer than wrought-iron keirs, but they last longer and resist the attacks of rust better.

When the fabrics to be boiled are very fine the interior sides of the keir are lined with wooden staves. By coating the outside of the keir with a non-conductive boiler composition the loss of heat is further diminished.

The column in which the lye circulates, at the bottom of which is the injector, may be fixed either on the side or in the centre. It is preferable to fix it in the centre, because the lye spreads and distributes itself more regularly on all sides;

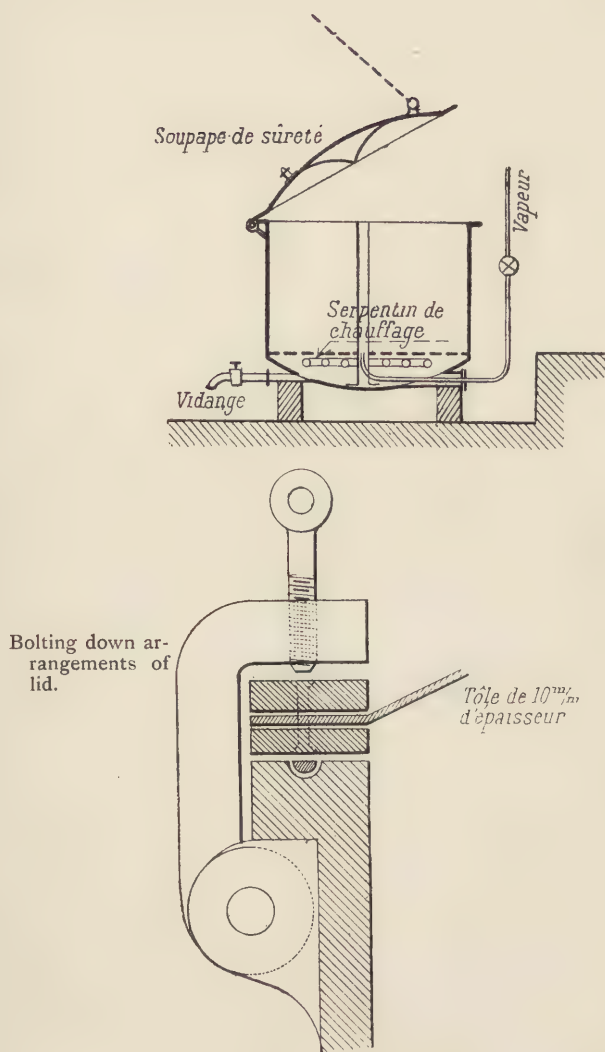


FIG. 6.—Cast-iron Keir.

Explanation :—

*Soupape de sûreté* = Safety Valve.*Vapeur* = Steam.*Vidange* = Discharge Pipe.*Serpentin de chauffage* = Steam Coil.*Tôle de 10<sup>m</sup>/<sub>m</sub> d'épaisseur* =  $\frac{2}{8}$  inch Iron Plate.



but this arrangement is sometimes rather awkward for the stacking of the fabrics in the keir.

The lid is made of sheet iron, the flanges rest between two circular bands of cast iron which impart rigidity to it, and through which pass the screws with which it is bolted down.

The lid is lifted up and let down by a chain and windlass. The lid is kept up by a wooden block so as to prevent accidents by the snapping of the chain.

When the lid is on, it is fixed by iron clamps and screws which bear upon the iron bands. There is a small channel on the flange of the keir, in which a layer of hemp is placed so as to make a tight joint. The space between the clamps is about 0·50 *metre* (say 20 inches) from axis to axis.

These keirs are generally very wide (2 to 3 *metres* in diameter, say  $6\frac{1}{2}$  to  $9\frac{3}{4}$  feet) and shallow (1·50 to 2 *metres*, say 5 to  $6\frac{1}{2}$  feet). They are badly adapted to stand pressure. They must therefore be made of very thick cast or wrought iron; on the other hand, they are handy for stacking the fabrics, especially when in bundles. The lid requires a large, free space for opening, the rollers therefore which deliver the fabrics into the keir and withdraw them ought to be fixed very high up.

The fabrics are kept pressed down by bars of iron which fit into notches cast on the pan when it was being made. If the pan be of wrought iron, pieces of angle iron are fixed to the pan, the flanges of which keep the bars in position.

A pan 2·60 *metres* in diameter (say  $8\frac{1}{2}$  feet) by 1·60 *metre* ( $5\frac{1}{4}$  feet) in depth may hold from 1,500 to 1,800 *kilogrammes* (say 3,375 lb. to 4,000 lb.) of fabrics, leaving on the top the necessary space for swelling up with the steam, say 0·30 *metre* (12 inches). The space occupied by the fabrics is from 6 to 7 cubic *metres* (say 210 to 250 cubic feet) or about 300 *kilogrammes* (say 675 lb.) of fabrics per cubic *metre* of 35·3 cubic feet.

*Pressure Keir with Circulation of the Lye by a Centrifugal Pump.*—In order to secure quick circulation of the lye, pumps are resorted to. Centrifugal pumps are best adapted for this purpose.

The circulation is thus independent of the steam supply, which is regulated so as to obtain a suitable temperature,

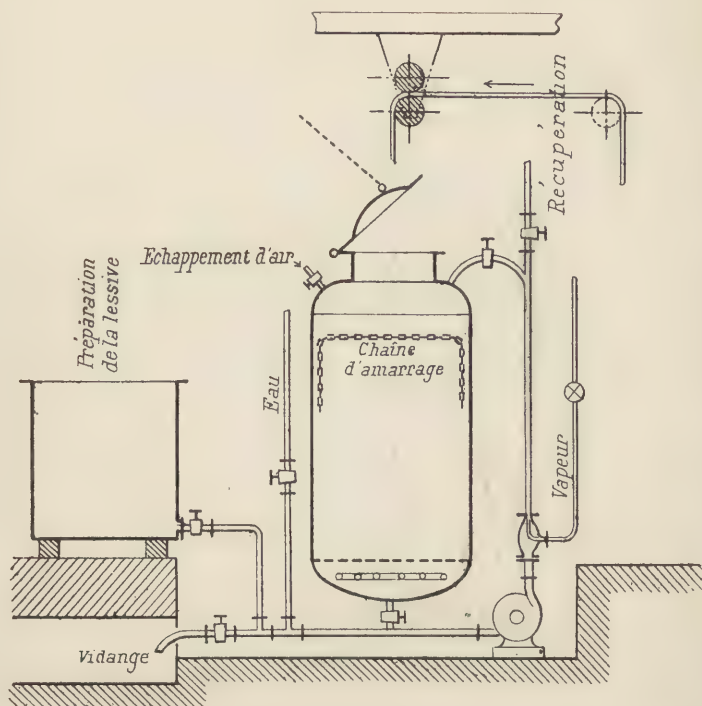


FIG. 7.—Pressure Keir.

Explanation :—

*Préparation de la lessive* = Lye Preparation Tank.

*Echappement d'air* = Air Valve.

*Chaîne d'amarrage* = Weighting down Chain.

*Eau* = Water.

*Vapeur* = Steam.

*Vidange* = Discharge Tap.

say 60° to 80° C. for the boiling of certain fabrics which require to be washed at low temperatures, or 100° to 120° C.

for boiling at high pressure in pressure pans. This cannot be done in pans where the circulation is effected by a steam injector fixed in the column which elevates the lye. If it be desired not to exceed a certain temperature the steam must be turned off and consequently the circulation interrupted. If, on the other hand, a high temperature be required more steam is turned on, but by-and-by the lye, becoming too hot, ceases to rise, and steam alone issues from the circulation column. The circulation stops also in closed pans when there is not enough difference between the pressure of the steam in the steam supply pipes and in the interior of the pan.

This system is still much employed because it requires no motive power, as in the case of a pump. Nevertheless the advantage of effecting the circulation of the lye by a pump has been so far recognised that its adoption is becoming more and more general.

Circulation can be effected by a pump, no matter what system of pan be used. The following very suitable arrangements give very good results. See Fig. 7.

The pan consists of a vertical wrought-iron cylinder, the top of which is closed by a lid, worked by a chain and windlass.

The lid is fastened by clamps tightened with screws, or by any other means strong enough to resist pressure.

The depth of the pan is about  $1\frac{1}{2}$  time its diameter. This ensures a better circulation of the lye throughout the whole of the pan. If the diameter of the pan be very great in proportion to the depth it is difficult for the lye to spread all over its surface, and it is to be feared that circulation is only effected in certain parts and not in all.

A pan the cylindrical portion of which is 3.30 metres (say 11 feet) in depth and 2.25 (say 7 feet) in diameter may contain 2,000 *kilogrammes* (say 4,500 lb.) of fabrics. The pieces

are delivered into the pan by a pair of rollers or cotton winders, fixed above the centre. The fabrics are kept down by wooden cross pieces, supported by wooden uprights. Chains also answer very well for this purpose. It is advisable not to press the fabrics too tight, but to leave them room to rise a little after the lye has been introduced; acting in this way the lye penetrates better and spots are avoided. This last observation, which has been verified by the author, was communicated to him by an English foreman.

The pan is furnished with a gauge glass to show the level of the lye, safety valve, manometer and steam blow off cock.

The pump ought to be placed as low as possible so as to work by propulsion and not by respiration. It takes the lye from the bottom of the keir and propels it to the upper part, and thus keeps the lye in constant circulation during the whole of the boiling process. The output of the pump should be such that the whole of the lye should be withdrawn and propelled in the space of twenty to thirty minutes. For example, if there be 4,000 *litres* (say 900 gals.) of lye to displace, the output of the pump should be  $\frac{4000}{20} = 200$  *litres* (say 45 gals.) per minute, or  $\frac{4000}{30} = 133$  *litres* (or 30 gals.) per minute.

The heat is supplied by a steam pipe fixed below the false bottom. It is still advantageous to lead the steam into the interior of the lye ascension column, the pipe being in the form of an injector. The steam heats the lye, and at the same time helps to circulate it. The lye is made in a tank communicating with the pan by means of a pipe. It is well to have this tank of the same capacity as the pan, so that the lye may be prepared of the exact strength at which it is to be used. The lye is pumped from the tank into the pan containing the fabrics. If it be not desired to have such a large tank, the strong solution of soda is made in a small tank, and this solution is run into the pan



simultaneously with water to dilute it. The whole is mixed by the pump, and the strength verified by a hydrometer.

Care must be taken before pumping the lye on to the fabrics to boil it in the tank in which it has been made,

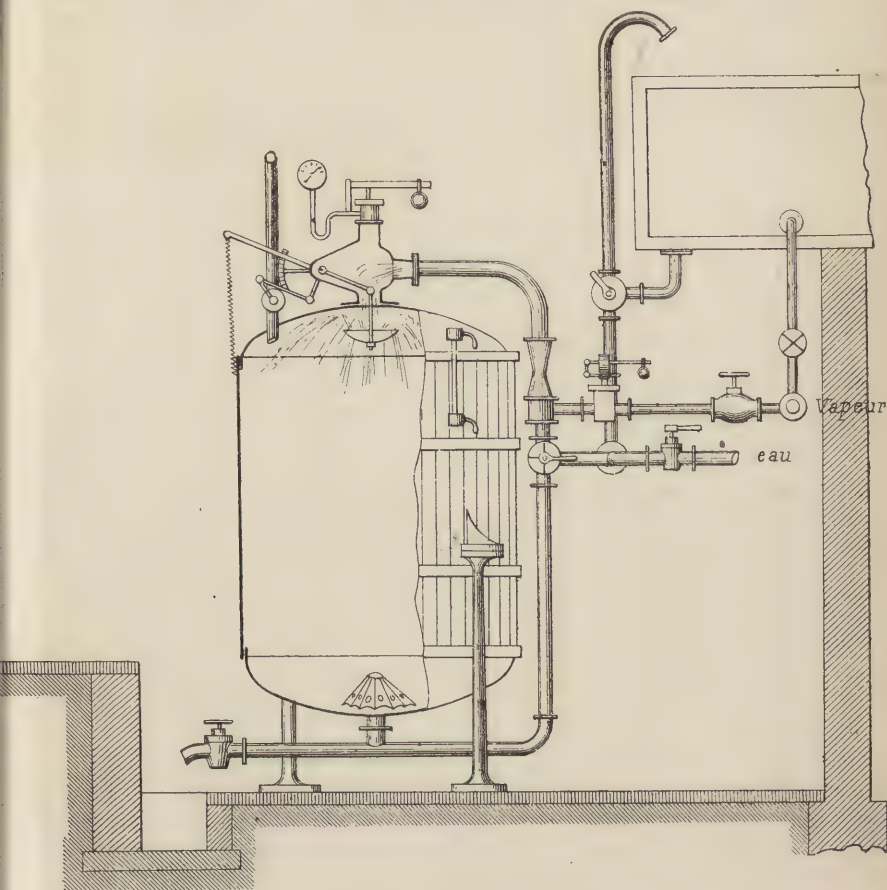


FIG. 8.—Farmer and Spendé's Keir, with Indicator and Automatic Circulation Regulator.

Explanation :—

*Vapeur* = Steam.

*Eau* = Water.

and to skim off all the impurities which float to the top in the form of scum. When the boiling is finished the lye is run off. If the soda be not all spent, it is economical to

pump it into a revivifying reservoir and to use it in another boiling, after having been revivified.

The *washing* in the keir may be done with either hot or cold water. The water may be heated in the tank in which the lye was prepared. It is run into the pan, circulated by the pump, and then run off. Washing with cold water may be done in the same way.

*Sir James Farmer's (Manchester) Keir.*

This pan, represented in Fig. 10, has certain features which render its use advantageous. It is distinguished by its indicator and automatic circulation governor.

*Pressure.*—The pan is constructed to work at high and low pressure; it is tested to work at a pressure of 2 kilogrammes per square centimetre (say a temperature of 120° C. and a pressure of 2 atmospheres). The fabrics are delivered into the pan in the usual way, and pass through two manholes, which allow of two lengths of cloth being introduced at the same time. These manholes are closed by hinged lids and screw bolts, so that no time need be lost in opening or shutting them. The pan can be used equally well for boiling with lime, salt of soda, or caustic soda, and is easily worked by a simple bleach works hand.

*Injector.*—The liquid is put in circulation by means of a special form of injector, which does away with the use of a pump, and is constructed in such a way as to spend as little steam as possible.

*Reducing Valve.*—It is advantageous to provide the keir with a reducing valve, which is fixed near to the injector. This facilitates considerably the watching of the progress of operations by the bleacher.

*Farmer's Governor and Indicator.*—The circulation is controlled by Farmer's automatic governor and indicator, which shows at each moment the force of the circulation, and prevents all stoppages due to equilibrium of pressure in the pan.

The indicator-governor consists of a plate pierced with holes, and in form of a bonnet (*grid bonnet*), which is hung on a rod at the end of a lever ; this lever moves an arm which issues from the exterior of the triangular box represented by the top of the keir. A stuffing box prevents the escape of steam. A lever is pivoted on this axis outside the box, and connects with a spring. According to the force of the vapour the plate stretches the spring more or less, and the exterior lever moves the length of a segment and shows at each moment the force of the circulation. Another small lever, pivoted on this same axis, is fixed by an articulated system to the key of an air valve. When the pan is ready to start work the air valve is connected by these levers to the governor. So long as the circulation is normal the air valve remains closed ; but as soon as it slackens, the spring raises up the movable plate, and partially opens the air valve. The difference of pressure between the steam in the keir and that in the generator is re-established, and the circulation resumes its normal force. The bleacher's attention is fixed on the working of his keir during the whole period of boiling, and he controls it by watching the oscillations of the lever.

*Introduction of the Steam.*—The fabrics may be heated to the boiling point by dry steam before running in the lye. In this way it is not reduced to any appreciable extent during the boiling. This reduction may be still further reduced by covering the outside of the pan with wooden boards which diminish the cooling surface, and consequently the condensation of steam in the lye.

*Valves and Pipes.*—All the valves and taps are easy of access. The three-way taps are provided with a copper dial indicating the directions.

The arrangement of the piping is such that numerous operations may be conducted.

A three-way tap placed below the injector allows of the following being put in communication :—

- (a) The bottom of the pan with the circulation injector.
- (b) The lye reservoir with the pan.
- (c) The bottom of the pan with an overhead pipe, to convey the lye into a reservoir if required.
- (d) The cold water cistern with the injector, to wash with cold water or to cool the pan.

*Hood.*—The hood, placed at the bottom of the pan, is conical in shape, with an undulatory surface to prevent the fabrics from obstructing the holes. Some bleachers line the bottom of the vat with twigs. The hood is admirably adapted for this purpose.

*Gauge Glass.*—This, instead of being placed on the steam or circulation pipe, as is customary with high pressure keirs, is fixed directly on the body of the pan, where it enables the quantity of liquid to be controlled from the beginning to the end of the operation.

*Method of Working the Keir.*—1. *Filling.*—The fabrics are introduced through the two manholes, two strands being delivered simultaneously; then the manholes are closed.

2. *Steaming.*—The steam valve is opened as well as the air escape and the discharge tap. When the air valve commences to let out steam it is closed and the steam kept on until the pan becomes hot and steam is seen to escape by the tap at the bottom of the pan. When the fabrics have been saturated with caustic soda it is advantageous to collect the water condensed during the steaming operation. In that case the discharge tap is closed and the bottom of the pan is brought into communication with the pipe leading to the overhead reservoir and the condensed liquid pumped up into it.

3. *Running the Lye into the Pan.*—The discharge pipe is closed, and the steam turned off immediately afterwards. The air valve is opened and the lye is then introduced into the pan, either by its own weight, by running through the three-way cock and entering the pan from below, or it may be



propelled by the injector and spread over the top of the fabrics. Enough lye ought to be run into the pan to partially float the fabrics.

4. *Circulation*.—The lye having been run in to the pan, circulation is started by putting the bottom pipes in communication with the injector through the three-way stop cock and turning on steam at full pressure. The air blow-off cock is then connected with the governor, and the boiling proceeds without any further attention.

5. *Washing*.—After the fabrics have been sufficiently boiled the steam is stopped, and the lye run off or pumped to the overhead reservoir to be again used. If the fabrics are to be washed in the pan, hot water from an overhead reservoir is run in, circulated a few times, and cooled.

6. *Cooling*.—In order to cool the pan, the bottom tap is opened and cold water is run over the fabrics by means of the injector. A partial washing with cold water is thus effected. The fabrics are then taken out of the keir to receive further treatment.

*Advantages of the Keir*.—1. The arrangement of the keir is adapted to the great number of processes in use by bleachers—boiling with lime, resinate of soda, pure caustic soda, etc.

2. It is simple and cheap, and the process may be advantageously applied to every description of high pressure pan at present in existence.

3. Circulation is absolutely certain, and the time required for boiling is reduced to a minimum.

4. Washing operations may be effected in this keir as perfectly as in any other.

#### THE DIFFERENT OPERATIONS OF LYE-BOILING.

*Arranging the Fabrics in the Pans*.—This is done in several ways :—

The first consists in arranging the packages upright and

pressing them equally. Care must be taken to slacken the cord by which each package is tied. A first tier is made, then a second, and so on. This arrangement is convenient in very wide, shallow keirs. The fabrics are then covered with a sheet, and kept in position by cross pieces or chains, so that the lye may not raise them up.

The second manner of charging the pan consists in fixing overhead rollers above the pan which draw the pieces, the end of the one attached to the end of the other, and discharge them into the pan. A workman arranges the folds with a stick, taking care to spread them equally and leave no empty spaces.

The pieces are weighted down and the lye run on them. The shaft of the delivery rollers carries three pulleys—one fixed and two free. One of the free pulleys carries an upright belt and the other a cross belt; by bringing one or other of these belts on to the fixed pulley the drawing roller may be caused to turn in two different directions, and it thus serves to deliver the pieces into the pan or to draw them out of it.

By one or other of these methods the fabrics are deposited in the pan and the lye is then run in. Sometimes the pan is filled with lye and the fabrics deposited therein, either by throwing them in in bundles, or by depositing them in bands or stripes. They are probed down with sticks. This method has one advantage: the fabrics are well impregnated with lye throughout their whole mass. As they are not pressed, there is no reason to fear unequal bleaching or spots from deposits of dirt. The inconvenience of the method is due to the difficulty which is experienced in immersing the fabrics, and to the small quantity which can be got into a pan.

*Saturation.*—When the pieces can be tacked together end to end it is advisable to pass the lengths through a small tank filled with lye, from which the rollers draw them into the keir. This operation is called saturation, and its object is to

impregnate the fabrics with lye ; it is easier to lay them in the keir and no imprisoned air is left in the folds. Instead of a small tank through which the lengths pass only once, a washing machine is made use of, the trough of which contains the lye. The lengths making three or four revolutions through the lye are more thoroughly saturated, and this saturation is rendered more perfect by the compression of the rolls. In the case of those keirs where two lengths are deposited simultaneously, the washing machine is also arranged to saturate two lengths at the same time. The lengths run in at the two ends of the rolls and come out in the centre. This arrangement is described under Mather's keir.

*Washing in the Keir.*—When the boiling is at an end, and the spent lye run off, it is advisable to give the fabrics a preliminary washing in the pan. The discharge tap is closed, hot water is turned on until the pan is full, and then it is run off ; then cold water is turned on and allowed to run away until it issues clear and colourless from the draw-off cock.

Instead of only running the water once through the fabrics, it is caused to circulate by the steam injector or the pump, and then it is run off through the discharge pipe. The same operation is repeated two or three times. Acting in this way a better result is obtained, only care must be taken not to stir up the dirt which has accumulated in the bottom of the pan and spread it over the fabrics.

When the fabrics are boiled with caustic lye the washing in the pan is not enough. If the next operation be exposure on the green, they must receive a further washing by machine. But if the lye be a carbonate of soda lye, and the fabrics fine and permeable, the bleacher may be content with washing in the keir before sending the fabrics to the chemick, or to exposure on the bleaching green.

*Salts Used to Make Lyes.*

*Caustic and Carbonated Alkalies.*—The salts most commonly used are: (a) caustic soda; (b) carbonate of soda; and (c) salt of soda, *sel de soude*, a mixture of caustic and carbonated alkali, the most general proportion of which is 15 to 20 per cent. of caustic soda and 80 to 85 per cent. of carbonate of soda.

Caustic soda is a very energetic solvent for colouring gummy and other substances, but it must be used with caution, so as not to attack the essential portion of the textile fibres. Above all, care must be taken not to allow it to act on the fabrics in contact with air, because they would be seriously deteriorated. The washings which follow lye-boiling (*débouillissage*) ought to be very thorough, especially if the fabrics are to be afterwards exposed on the bleaching green. If they retain the smallest proportion of caustic, it is quite sufficient to destroy them. In his examples of treatment the author gives the degrees of concentration which he thinks most suitable.

Carbonate of soda has the same solvent properties for gummy matters as caustic soda, but its action is much slower. There is little danger of injuring the fibre of the fabrics. When treating fabrics woven with various colours it is dangerous to use even weak caustic soda lyes, because certain colours do not stand their action. It is prudent only to use carbonate of soda lyes.

Salt of soda is intermediate between caustic soda and carbonate of soda. It is the salt which is most frequently used in bleaching. To work with pure caustic soda requires special plant and a very skilful staff of employees. If only carbonate be employed, operations must be multiplied, and still a proper white is not attained. Practice has demonstrated that salt of soda is safe enough in its use, and yields good results.



Caustic potash and carbonate of potash have the same properties as caustic soda and carbonate of soda. They are less frequently used on account of their higher price.

*Lessive Phénix.*—The “lessive Phénix,” very much used in boiling linen, contains silicate of soda. The author does not know what are the special properties of silicate of soda from a bleaching point of view, but he has used the “lessive Phénix” for bleaching coarse Normandy sheeting with very good results. The “lessive Phénix” has a more energetic action than carbonate of soda, and has not the same injurious effects as caustic soda. It answers very well for coloured fabrics.

*Alkaline Sulphides, Sulphites and Bisulphites.*—Of all the solvents for the colouring principles of cotton and linen, the alkaline sulphides are the most energetic. Soda and potash rank but second. The difficulty in the use of alkaline sulphides is their destructive action on metallic pipes. Then again there is the decomposing action of chlorine, if the washings have not been thorough. Consequently they are not available, except when followed by a second washing with alkaline lye, or by an operation, which is not bleaching, with chlorine. The sulphides give a very pronounced white, but act strongly on the textile fibres. Some bleachers add successfully a little sulphite or bisulphite of soda to the soda lyes. The bisulphite of soda is added to the lye in the proportion of one-sixth of the weight of the caustic soda.

*Concentration of the Lyes.—Methods of Estimation.*—The strength of the lyes depends on their concentration, which is proportional to the amount of salt dissolved per cubic *metre*. The strength is estimated in France by degrees Baumé. The degrees Baumé refer only to the density of the lye, but not to its strength properly so called, that is to say, to its alkali-metrical strength, or the impurities which it may contain. To ascertain, for example, the real quantity of carbonate of soda

or caustic soda contained in a lye, resort must be made to methods of chemical analysis.

These methods are explained in a chapter devoted to alkalimetry.

For the same quantity of salt dissolved, the density varies with the nature of the salt ; it is therefore necessary to prepare a table indicating the number of *kilogrammes* of this salt which must be dissolved in 1,000 *litres* of water so as to have the corresponding degree Baumé.

In the following table the author gives those quantities for the salts most frequently used in France : (a) Solvay carbonate of soda 90° to 92° Descroizilles ; (b) salt of soda, a mixture of caustic soda and carbonate of soda, 82° Descroizilles, containing 20 per cent. of caustic soda ; (c) caustic soda 112° Descroizilles. The indications go from 0° to 3° Baumé, because it is rare that more concentrated lyes are made.

NUMBER OF KILOGRAMMES OF DIFFERENT ALKALINE BODIES  
TO BE DISSOLVED IN 1,000 LITRES, OR OF LB. IN 100  
GALLONS, OF WATER TO OBTAIN AN ALKALINE  
LYE OF A CERTAIN DENSITY.

Degrees Baumé.	Weight in <i>Kilogrammes</i> per 1,000 <i>Litres</i> , or in lb. per 100 Gallons, of Water.		
	Carbonate of Soda.	Salt of Soda.	Caustic Soda.
0	0	0	0
0·5	4	4	3·25
1	8	8	6·75
1·5	12·5	12	9·25
2	16	15	12·0
2·5	20	19	14·25
3	23·5	23	17

The use of the hydrometer is very convenient, because all that is required is to plunge it in the lye cooled to 15° C., and then deduce from the table the alkali which it contains per cubic *metre*, and thus ascertain its strength. But conclusions must not be drawn from this which the hydrometer does not show.

The divisions of Baumé's hydrometer are made in such a manner that, plunged in pure water at 15° C., it marks 0°, and when plunged into a solution of salt containing 15 per cent. of common salt it marks 15°. The space between 0° and 15° is divided into three equal parts, and these equal divisions are continued above 15° C. It is quite an arbitrary division, and to know the density corresponding to a given degree Baumé resort must be had to another table giving the densities corresponding to the degree Baumé.

COMPARATIVE TABLE OF THE DEGREES OF THE HYDROMETERS OF BAUMÉ, TWADDELL AND BECK, CORRESPONDING TO THE SAME DENSITY.

Density.	Degrees.			Density.	Degrees.		
	Baumé.	Twaddell.	Beck.		Baumé.	Twaddell.	Beck.
I	0	0	0	I'190	23	38	
I'007	1	1'4		I'199	24	40	29
I'014	2	2'8		I'210	25	42	
I'022	3	4'4			26		
I'029	4	5'8			27		
I'036	5	7'2			28		
I'044	6	8'8		I'250	29	50	34
I'050	7	10	8		30		
I'060	8	12			31		
I'067	9	13'4			32		
I'075	10	15			33		
I'083	11	16'6		I'300	34	60	40
I'091	12	18'2			35		
I'100	13	20	16	I'350	38	70	44
I'108	14	21'6		I'400	41	80	49
I'116	15	23'2		I'450	45	90	53
I'125	16	25		I'500	48	100	57
I'134	17	26'8		I'530	50	106	59
I'143	18	28'6					
I'150	19	30	23				
I'161	20	31'2					
I'171	21	34'2					
I'180	22	36					

When the degree Baumé of a lye is taken the experiment must be made at 15° C. If the hydrometer were plunged in a hot lye the indications would be altogether erroneous.

The British use Twaddell's hydrometer, the Germans Beck's. The above table gives the relations between the densities and the degrees of these different hydrometers:—

When the Baumé hydrometers are divided from  $0^{\circ}$  to  $40^{\circ}$ , for example, the divisions are very small and do not allow of ascertaining accurately enough the strength of a lye. A hydrometer graduated from  $0^{\circ}$  to  $4^{\circ}$ , for example, should be used, divided into degrees and tenths of degrees. This hydrometer is only available for lyes the concentration of which does not exceed  $4^{\circ}$ , but that suffices in practice because stronger lyes are not used.

*Proportion between the Weight of Soda and the Weight of the Fabrics.*—The degree Baumé gives the strength of the lye, that is to say the energy—greater or less—with which it attacks the soluble portion of textile fabrics, but it is necessary also to proportionate the weight of alkali to the weight of the fabrics. If for a large quantity of fabrics a small quantity of lye be used, it will be exhausted in a short time, and the boiling will not produce the desired effect; if, on the contrary, a large volume of lye be used for a small quantity of fabrics, much alkali will remain in the lye and a useless expense be incurred. The custom is to dissolve in the water the quantity of alkali required for the lye to mark the desired degree Baumé; then a quantity is run into the pan sufficient to completely immerse the fabrics. Weight for weight fabrics occupy different volumes according to their nature; it follows that the volume of lye required to cover the same weight of fabrics is also variable. Experience teaches that 100 *kilogrammes* of cloth require 600 *litres* of lye, say 60 gallons of lye per 100 lb. of cloth, and the following table is calculated on that fact:—



TABLE SHOWING THE PERCENTAGE OF ALKALI ON THE WEIGHT OF THE FABRICS ACCORDING TO DENSITY OF LYE.

Degrees Baumé.	Per 100 <i>kilogrammes</i> or 100 lb. of Fabrics.	
	Carbonate of Soda or Salt of Soda.	Caustic Soda.
	<i>Kilos. or Lb.</i>	<i>Kilos. or Lb.</i>
0·5	2·4	2
1	4·8	4
1·5	7·2	5·6
2	9·6	7·2
2·5	12	8·6
3	14	10·2

By pressing the fabrics in the pan a larger quantity may be packed into it and thus the amount of lye may be reduced, but this method of working is not advantageous. This proportion of 600 *litres* of lye for 100 *kilogrammes* of fabrics is a good one and should not be departed from too widely.

*Method of Preparing Lyes.*—When a lye has to be prepared it is necessary to know the amount of water required to submerge the fabrics and the degree Baumé; from that the quantity of alkali to be used is deduced. For example, if it be desired to make 3,000 *litres* of carbonate of soda marking 2° Baumé, it will be seen, on consulting the table, that it will be necessary to dissolve  $3 \times 16 = 48$  *kilogrammes* of carbonate of soda. The most convenient method of preparing lye would be to have a tank alongside the keir equal to it in capacity, in which the lye could be prepared of the strength at which it is to be used. It is not always possible to provide such a large tank. If only a small tank be available the necessary quantity of alkali is dissolved in it, so that when once it has reached the keir it may be diluted to the desired degree Baumé. This concentrated solution is pumped into the pan and water run in simultaneously, and then with a pump, or an injector, the whole is circulated so as to thoroughly mix the lye, a sample of which is taken and

tested from time to time until the desired degree Baumé is obtained. The alkali is rather difficult to dissolve; when it is run into the water it aggregates into a mass which is afterwards difficult to dissolve. Solution is facilitated by the use of a cage, the interior of which is lined with wire gauze. This cage has been described when giving instructions in regard to dissolving lime, pp. 26 *et seq.* It is fixed above the tank in which the alkali is dissolved and is made to partly dip into the water. The alkali is run into the cage and stirred with a rake to dissolve it and to cause it to pass through the meshes of the wire gauze. Its aggregation into masses in the bottom of the tank is thus prevented. When all the alkali is dissolved it is boiled; a quantity of impurities mount to the surface under the form of scum; these are removed with a scraper, and the solution pumped to the keir.

*Revivifying the Lye.*—When boiling is at an end the lye is run off. When the lye has been used for brown unbleached fabrics, it is highly charged with substances which it has dissolved. The alkali which it contained has been exhausted, there is therefore no object whatever in preserving it. It is not so, however, when the lye comes from the boiling of fabrics which have been previously boiled with lye three or four times; it then still contains a greater or less quantity of alkali which can be utilised in another operation. Instead of running the lye away it should be pumped to a reservoir, and the quantity of alkali added to it which has been used up in the previous boiling.

In order to ascertain the unexpended strength of an old lye, Baumé's hydrometer is of no use, as the dissolved substances have increased its density. A lye shows greater density by the hydrometer at the end of a boiling than it did at the commencement. The strength of the old lye has to be tested by the alkalimetric method described in Chapter XIII. It would take up too much time to make these tests

after each boiling. They are done on two or three occasions, and an amount of alkali added to the old lye equal to that which was absorbed in the previous boiling process. The density is taken by the hydrometer to see whether the lye has increased in density in proportion to the amount of alkali added.

*Temperature of the Lyes.*—The solvent property of lyes increases with the temperature. When boiling is conducted with access of air the temperature never exceeds 100° C., but in autoclave keirs the temperature rises with the pressure, and therein lies the advantage which results from boiling under pressure. The following table gives the temperature corresponding to the pressure :—

Temperature of the Vapour.	Tension of the Vapour		Pressure in Kilogrammes per sq. Centimetre.
	In Atmospheres.	In Columns of Water.	
100°00	1°00	10°334	1°033
106°33	1°25	12°917	1°292
111°33	1°50	15°501	1°550
116°50	1°75	18°084	1°808
120°64	2°00	20°668	2°067
124°39	2°25	23°251	2°325
127°33	2°50	25°835	2°584
130°98	2°75	28°418	2°842
133°91	3°00	31°002	3°100
136°72	3°25	33°585	3°358
139°29	3°50	36°169	3°617
141°72	3°75	38°752	3°875
144°00	4°00	41°336	4°134

Pressure gauges (manometers) specially intended for lye-boiling pans are made. The gradation is made in *kilogrammes* and in tenths of *kilogrammes*, and the corresponding temperature is indicated opposite.

With linen and cotton fabrics the temperature does not exceed 120° C. In the examples of treatment the temperature which the author considers most suitable is given for each boiling.

When coloured fabrics are being treated temperature plays an important part. Thus, the author has remarked that a carbonate of soda lye at 1° Baumé, and heated to 75° C., produces the same effect as a lye at 2° Baumé heated to 60° C. A lye which contains a little caustic soda has a much more energetic effect than a lye containing carbonate of soda alone, and should not be heated so strongly. There are certain colours—blue, for example—which stand the action of carbonate of soda very badly.

*Length of Time occupied in Boiling.*—When, during a boiling, samples of the lye are taken from time to time, and the strength tested alkalimetrically, it is seen that the soda goes on decreasing and that at the end of a certain time the diminution in strength stops. It is then time to stop the boiling, as the lye is doing no more work. The results of the tests made by the author are given in the chapter devoted to Mather's keir. The bleacher would derive great profit by repeating them, so as to determine the useful duration of boiling, because the lye works differently according to its degree of concentration, its temperature, the quantity and the nature of the fabrics. These tests, although simple, are delicate enough to carry out; experience especially determines the time boiling lasts. It is generally stopped as follows: after seven to eight hours for unbleached goods, that is to say, for the boiling with lye preceding the chemick, and three to five hours for white fabrics, that is to say, for the boiling with lye which follows the chemick.



## CHAPTER V.

### MATHER AND PLATT'S KEIR.

DESCRIPTION OF THE KEIR.—PRINCIPLES ON WHICH THE KEIR IS WORKED.—LYE-BOILING.

SATURATION OF THE FABRICS.—*Roller Saturating Machine—Saturating Cistern.*

ALKALI USED IN LYE-BOILING.—*Quantity of Alkali to be used for given Weight of Fabric—Soap—Duration of Lye-boiling—Manipulation and Revivification of the Lye.*

EXAMPLES OF PROCESSES.—*Fine White, Muslins and Cambric Handkerchiefs—Household White (blanc de ménage), Muslins and Cambric Handkerchiefs—Cholet White (blanc de Cholet), Muslins and Handkerchiefs—Fine du Nord and Irish Linens—Cotton Goods, Piqués secs and Swanskin Piqués; Quilts and Ribbons; Calicoes, Millinery, Jaconets.*

SOME ten or twelve years ago Mather and Platt, of Manchester, put on the market a keir by the use of which important advantages are obtained. How time, chemicals and fuel may be economised by the use of this keir is evident from the description of the principle on which it works, as well as by the treatment which the fabrics are made to undergo.

### DESCRIPTION OF MATHER AND PLATT'S KEIR.

See Fig. 9. The keir consists of a wrought-iron cylinder placed horizontally. At one extremity there is a door which is worked by hydraulic piston. Inside the keir, rails are laid in communication with hinged rails which connect

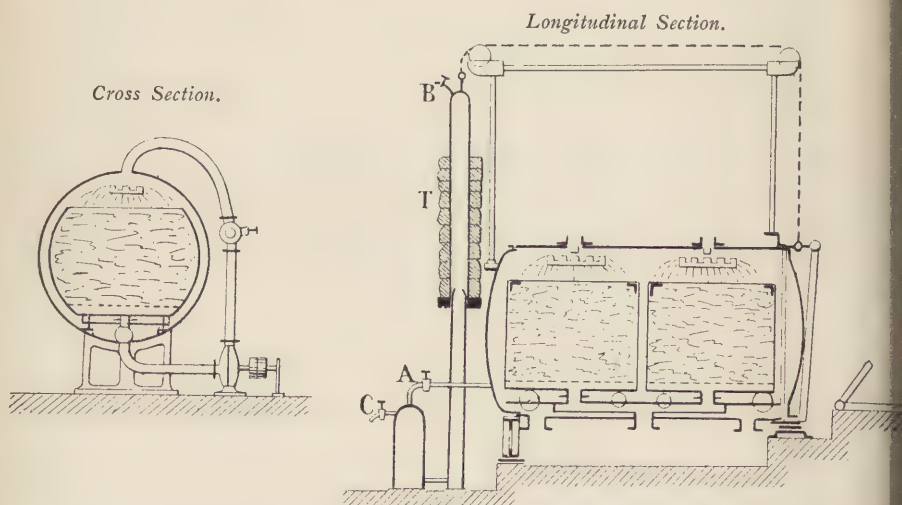
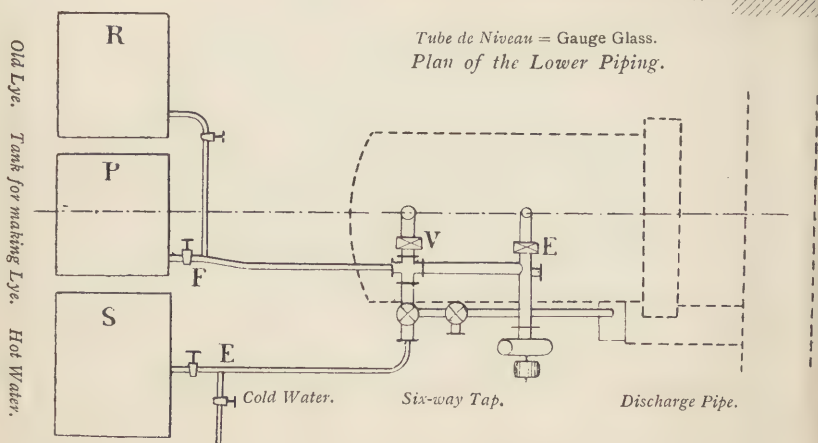
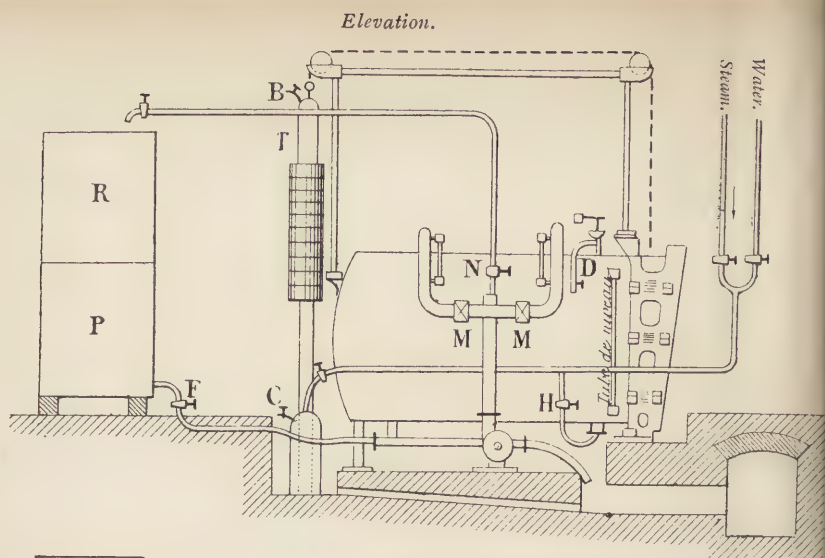


FIG. 9.—Mather's Keir.

with outside rails, and it is on these rails that the waggons, filled with fabrics or other material to be bleached, circulate in and out. These waggons are made of galvanised sheet iron, and are provided with a perforated false bottom. The circulation of the lye is effected by a centrifugal force-pump. The re-issue pipe is divided into two branches so as to spread the lye evenly over each waggon. At the point where it is spread over the waggons, a plate of cast iron breaks the current and causes it to spread itself in the form of rain. The bottom of the waggons is put in communication with a collecting conduit through which the lye returns to the pump.

On the side of the pipes which spread the lye over the waggons, glass indicators are fixed so that the man in charge may be able to see whether the circulation is going on all right or not. A level tube or gauge glass shows the height of the lye inside the tube.

The lye is heated by a closed steam coil placed in the bottom of the keir. The condensed water from the steam runs away on the outside so as not to dilute the lye. The lye may also be, and most generally is, heated with direct steam by the means of a perforated steam coil, the steam heat being thus more fully and beneficially utilised.

The waggons are taken out of the keir by a winch, chain, and pulleys suitably fixed, by means of which also the waggons may be transferred to any desired place. Turntables are placed at the intersection of the line of rails. The door is wedge-shaped and fits into a frame with inclined sides or edges. In this manner the door is wedged in when it is brought down to the shutting position, and it is kept in that position by a cam worked by a lever. The door is balanced by a weighted cylinder to which it is attached by a chain passing over pulleys. The cylinder slides on a hollow hydraulic piston, the bottom of which communicates

with the lower part of a pressure reservoir. To close the door, steam is introduced into the upper part of this reservoir, and the steam presses on the water; this pressure is transmitted by the water to the hollow mobile cylinder; it rises and the door descends by its own weight.

*Accessories.*—The accessory plant required for Mather's keir consists of:—

A tank or cistern for preparing the lye, P.

A revivifying reservoir, R, for the old unexhausted lyes which can be used over again.

A hot water reservoir, S, for washing in the keir.

A small cast-iron tank for the concentrated soda lye of 33° to 35° Baumé.

#### PRINCIPLES ON WHICH THE KEIR WORKS. (See Fig. 9.)

The waggons charged with fabrics having been run into the keir, the door is closed.

*Method of Closing the Door.*—Open the tap B to let out the air, let the water run in by the tap A until it is seen to issue from the tap B. Close this latter tap, then introduce steam through the tap A. The pressure of the steam causes the cylinder, T, to rise up, and the door then descends by its own weight, and is wedged up by the eccentric wheel. This done, the steam and water are allowed to escape by the gauge tap, C.

*Boiling.*—In order to start boiling leave the tap D open for the air to escape. Close the tap E. Open the tap F of the lye preparation tank. Set the pump to work. The lye falls on the top of the waggons. When all the lye has been pumped in, say about 4,000 litres per 2,000 kilogrammes of fabrics (say 400 gals. per 2,000 lb.), the tap F is closed and the tap E opened so as to start the circulation. Steam is introduced by the tap H, leaving the tap D open for the



escape of the air chased out and replaced by the steam. Steam is led on when the coil in the bottom of the keir is replaced by lye; only a small jet of steam is put on to keep up the temperature of the lye, which is cooled by contact with the fabrics. When all the lye has been pumped into the keir the steam is laid full on, and the process goes on in this way (always keeping up communication with the atmosphere) for an hour if the fabrics have been saturated with lye before being piled in the waggons, and for two hours if they have not been so saturated. Then the tap D is closed, and the pressure is raised to correspond with the temperature which it is desired to impart to the lye. As soon as this pressure is obtained the steam is so regulated as to maintain the pressure during the boiling, which lasts from four to eight hours.

At the end of that time the lye is run off by opening the exit tap V. The pump is kept at work during the time the lye is being run off. The steam tap is shut off after the lye is run off, so that the pressure may fall. If the lye is to be revived, the taps M are closed and the taps N opened, and the lye pumped into the revivifying tank.

*Washing in the Keir.*—For the purpose of washing, the hot water reservoir is put in communication with the pump. About 4,000 *litres* of water are run in for the typical example of 2 tons of fabrics. Circulation is kept up for one half-hour, and the wash water then run off. Four thousand *litres* of fresh water are then run in, circulated for half an hour, and run off as before. If cold water be run in, it must be heated in the keir by steam, because cold water does not wash the fabrics well.

When the washing is finished, the door is opened and the waggons run out.

*Method of Opening the Door.*—In order to raise it gently, open the tap B to allow the air to escape; run in water

through the tap A until it runs out through the tap B (the water should be run in under pressure so as to fill the piston, T); close the taps B and A, unwedge the eccentric of the door, and open the purging cock, C. As the cylinder, T, is heavier than the door, it falls, causing the door to ascend, and pressing the water through the tap C. It will be seen that the speed at which the door is raised may be regulated by the tap C.

The waggons, as they come from the keirs, are brought in front of the roller washing machines, which draw the fabrics from the waggons and wash them. When treating hanks of linen or cotton yarn, ribbons, quilts, etc., the fabrics are taken from the waggons by hand and washed in special machines.

If the fabrics are to be chemicked after lye-boiling without being spread out on the bleaching green, the washing in the keir suffices; should any soda remain it will only render the action of the chemick a little slower.

#### LYE-BOILING WITH THE MATHER KEIR.

The principal advantage of the Mather keir consists in its allowing of the lye-boiling of fabrics, without risk, with soda absolutely caustic. This soda has a much more energetic action than salts of soda, which are a mixture of carbonate of soda and caustic soda. A more pronounced white is thus obtained with fewer operations. But in order to work with safety with caustic soda it is necessary, at all hazards, to prevent the air being imprisoned inside the fabrics during the boiling. A good precaution is to impregnate the tissues with caustic before piling them in the waggons. It is also necessary to expel the air from the keir before putting on the pressure for boiling at a high temperature. This is done by opening a tap communicating with the outside air until the steam expels the air from the interior of the vat and takes its place. This tap is then closed, and the pressure

raised so as to obtain a higher temperature. Finally, when the boiling is finished the fabrics must be well washed, either inside the keir, or after having withdrawn them from the waggons. Either operation is an excellent precaution. The fabrics are thus prevented from drying in contact with the air whilst impregnated with caustic soda, which would be very prejudicial to them.

The author insists specially on this point because he has seen fabrics burnt by caustic soda under circumstances such that he has been able to attribute it solely to the action of the air imprisoned in the fabrics. On taking precautions to prevent this the fabrics remained perfectly sound.

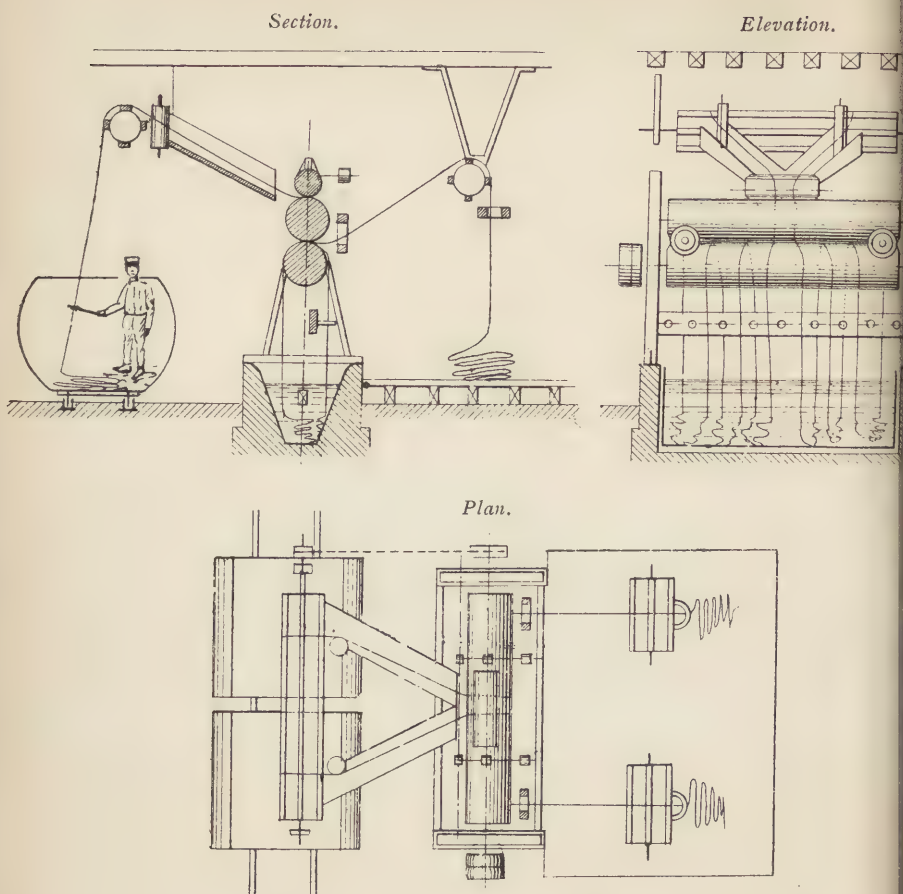
Before chemicking it is very advantageous to boil the fabrics in a soda lye purely caustic, and, further, if this be not done one of the great advantages of the Mather keir is lost.

Carbonate of soda, without any addition of caustic, is usually preferred for the lye-boilings after the chemick.

The use of salt of soda is not very judicious, and that for two reasons: in the first place, when caustic soda injures the fabrics it must not be used at all, and carbonate of soda alone is used; in the second place, where caustic soda is attended with no risk, then it is preferable to use it pure, and of a suitable strength so as not to damage the fabrics. For example, it would be preferable to replace a salt of soda lye of  $2^{\circ}$  Baumé by a caustic soda lye of  $0.5^{\circ}$  to  $0.8^{\circ}$  Baumé. Greater economy and a more beautiful white is obtained.

#### SATURATION OF THE FABRICS.

The object of this operation is to impregnate the fabrics with lye before piling them in the waggons. If hanks of yarn, or linen or cotton ribbons are to be treated they are first plunged into a lye of salt of soda, or of caustic soda; they are then arranged in the waggons, packing them regularly in such a manner that during the boiling the lye circulates throughout



*Saturating Beck.*

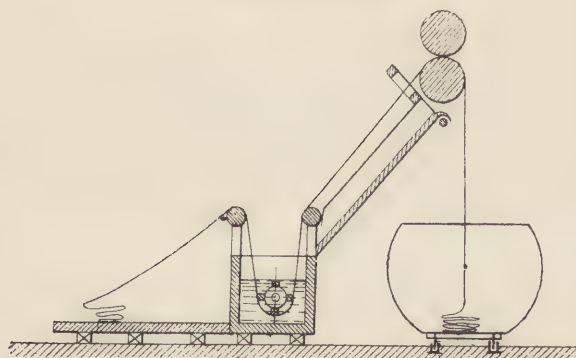


FIG. 10.—Roller Alkali-Saturating Machine.



the whole mass, and does not simply pass through the less tightly packed portions, leaving the other parts untouched.

*Saturating Roller Washing Machine.*—See Fig. 10. When the fabrics can be tacked on to each other, end to end, a roller washing machine is used, into the beck of which the lye is run. A single roller machine can fill two waggons simultaneously. The fabrics are delivered into the waggons which brought them, or on to a wooden board where they have been deposited. The rolling machine delivers two lengths at the same time; “pot eyes” guide their entrance; they issue forth in the centre. Reels deliver a strand in each waggon, where they are packed by a boy by aid of a stick. The lengths are guided between the rolling washing machine and the delivery reels by wooden gutters or shoots, down which the lye runs back into the beck of the roller washing machine. Each length makes three circulations through the machine, and the squeezing it undergoes between the rollers causes the lye to penetrate into the interior of the fabric. The linear speed of the length is about 5,000 *metres* (say 3 miles) an hour. Working with two pieces, and taking different stoppages into account, the two waggons may be filled with 500 pieces of cambric of an average length of 18 *metres* (say 59 feet) and of a total weight of about 2,200 *kilogrammes* (say 4½ tons) in two hours.

*Saturating Beck.*—A simpler method is to have a saturating beck filled with lye, through which the fabrics traverse, and two winding rollers deliver them into the waggons. The lye runs back into the beck down a wooden shoot (see Fig. 10). This plan is cheaper and occupies less room than the former, but saturation is not so well effected.

#### ALKALI USED IN LYE-BOILS.

As has been already said, caustic soda, salt of soda and carbonate of soda are used in lye-boiling.

The caustic soda used by the author was of the strength of 110° Descroizilles, and contained:—

	Per cent.
Caustic Soda $\text{NaHO}$ - - - - -	89
Impurities - - - - -	11
	<hr/> 100 <hr/>

The salt of soda of 80° Descroizilles contained :—

	Per cent.
Caustic Soda $\text{NaHO}$ - - - - -	20
Carbonate of Soda $\text{Na}_2\text{CO}_3$ - - - - -	59
Impurities - - - - -	21
	<hr/> 100 <hr/>

The carbonate of soda was Solvay soda ash, and contained :—

	Per cent.
Carbonate of Soda - - - - -	99.0
Impurities - - - - -	1.0
	<hr/> 100.0 <hr/>

The following table gives the weight of these different salts which it is necessary to dissolve in 1,000 *litres* of water so as to get the corresponding degree Baumé. This degree varies according to the composition of each sample of alkali and the impurities which it contains. For each alkaline substance of different composition this correspondence must be determined. Practically, the table is sufficiently exact. The weight of alkali to dissolve to obtain the tenths of degrees between the intervals can be calculated by proportion.

Degrees Baumé.	Weight per 1,000 <i>litres</i> of Water. <sup>1</sup>		
	Carbonate of Soda.	Salt of Soda.	Caustic Soda.
	<i>Kilos.</i>	<i>Kilos.</i>	<i>Kilos.</i>
0	0	0	0
0.5	4	4	3.25
1	8	8	6.75
1.5	12	11.5	9.25
2	16	15	12
2.5	20	19	14.25
3	23.5	23	17

<sup>1</sup> *Kilos.* per 1,000 *litres* = *lb.* per 100 *gals.*

*Quantity of Alkali in Proportion to Weight of Fabrics.—*

This second point has also to be considered. In fact, if the lye, being of suitable strength, be too small in quantity, it will be quickly exhausted, and the latter part of the boiling process will produce no effect. If too much be employed a useless and exaggerated expense for chemicals is incurred.

In the examples of different processes about to be given it is presumed that the keir has such a capacity that 2,000 *kilogrammes* of fabrics may be treated at a single operation. For that quantity 2,500 *litres* of lye will be required for saturation and 3,500 *litres* for boiling, say a total of 6,000 *litres*. Under these conditions the three following columns give the percentage of chemicals in proportion to the weight of the fabrics, corresponding to the degree Baumé at which the lye has been prepared :—

Carbonate of Soda.		Salt of Soda.		Caustic Soda.	
Degree Baumé.	Per cent. on Weight of Fabrics.	Degree Baumé.	Per cent. on Weight of Fabrics.	Degree Baumé.	Per cent. on Weight of Fabrics.
0	0	0	0	0	0
0.5	1.2	0.5	1.2	0.5	1
1	2.4	1	2.4	1	2
1.5	3.6	1.5	3.5	1.5	2.8
2	4.8	2	4.5	2	3.6
2.5	6	2.5	5.7	2.5	4.3
3	6.8	3	6.32	3	5.1

For example, for a carbonate of soda lye of 2° Baumé it requires (table 1) 16 *kilogrammes* of carbonate of soda per 1,000 *litres* (say 16 lb. per 100 gals.). Therefore, for 6,000 *litres* it will require  $6,000 \times 16 = 96$  *kilogrammes* (say 96 lb. per 600 gals.), and as that quantity will lye-boil 2,000 *kilogrammes* (say 4 tons) of fabrics the percentage will be  $\frac{96}{20} = 4.8$ .

*Soap.*—For the lye-boils before the chemick rosin soap is generally employed, because it costs less, and because at a high temperature the resinates of soda have special solvent properties. It is not prudent to use rosin soap for the boilings which follow the chemick, as there is then the risk of spots from unsaponified rosin. Olein soap or white soap should be used. When the fabrics have passed through the soap rubbing machines it is useless to add soap to the saturation lye, as the fabrics are already impregnated with it. In other cases it is put in the two lyes. The quantity of soap to use is 1 to  $1\frac{1}{2}$  *kilogramme* per 1,000 *litres* of lye (say 1 to  $1\frac{1}{2}$  lb. per 100 gals.).

*Duration of the Lye-boiling.*—Matters must be so arranged that the lye-boil does not exceed ten hours, so that two batches may be treated in twenty-four hours, and time allowed for the entrance and exit of the waggons, and the getting ready of the keir.

The following course may be adopted, which represents the maximum length of time occupied in the process :—

	HOURS.
Boiling at the atmospheric pressure - - - - -	1
In getting up the pressure - - - - -	$\frac{1}{2}$
Boiling under pressure - - - - -	6
Running off or recovering the lye - - - - -	$\frac{1}{2}$
First washing in the keir - - - - -	1
Second washing in the keir - - - - -	1
	<hr/>
	10
	<hr/>

The nearer the fabrics approach white the shorter should be the lye-boil. The useful duration of each boiling has been determined by the following experiments.

*Working of the Lye and Recuperation.*—The undernoted results show how the lye acts, and have enabled the conclusions detailed further on to be deduced therefrom.

1. Unbleached raw cambrics, first caustic soda lye-boil, at 2·8 per cent. on weight of fabrics.



Boiling at 118° C.	Degrees Baumé.	Alkalinity.
Fresh lye - - -	1'5	1'15
After 2 hours - - -	1'6	0'78
After 5 hours - - -	1'7	0'30
After 6 hours - - -	1'8	0'20

2. Cambrics, second lye-boil with caustic soda, at 2'8 per cent. on weight of fabrics.

Boiling at 118° C.	Degrees Baumé.	Alkalinity.
Fresh lye - - -	1'5	1'15
After 2 hours - - -	1'6	0'90
After 4 hours - - -	1'6	0'75
After 6 hours - - -	1'7	0'60
After 7 hours - - -	1'8	0'60

3. Cambrics, lye-boil after the first chemick with carbonate of soda, at 4'5 per cent. on weight of fabrics.

Boiling at 105° C.	Degrees Baumé.	Alkalinity.
Fresh lye - - -	1'8	1'30
After 2 hours - - -	1'7	1'10
After 4 hours - - -	1'7	0'85
After 6 hours - - -	1'7	0'84
After 7 hours - - -	1'7	0'84

4. Cambrics, lye-boil after the second chemick, with 3 per cent. of carbonate of soda on weight of fabrics.

Boiling at 105° C.	Degrees Baumé.	Alkalinity.
Fresh lye - - -	1'2	0'88
After 1 hour - - -	1'2	0'85
After 2 hours - - -	1'2	0'76
After 3 hours - - -	1'2	0'70
After 4 hours - - -	1'2	0'70
After 5 hours - - -	1'2	0'70
After 6 hours - - -	1'2	0'70

5. Cottons (piqués, ribbons, etc.), lime-boiled, and in first lye-boil, with 5 per cent. of caustic soda on weight of fabrics.

Boiling at 118° C.	Degrees Baumé.	Alkalinity.
Fresh lye - - -	3	1'90
After 2 hours - -	2'3	1'50
After 4 hours - -	2'4	1'35
After 6 hours - -	2'3	1'28
After 8 hours - -	2'3	1'18
After 10 hours -	2'2	1'12

6. Cottons (piqués, ribbons, etc.), in second lye-boil, with 5'7 per cent. of salt of soda on weight of fabrics.

Boiling at 118° C.	Degrees Baumé.	Alkalinity.
Fresh lye - - -	2'6	1'80
After 2 hours - -	2'4	1'66
After 4 hours - -	2'3	1'59
After 6 hours - -	2'3	1'45
After 8 hours - -	2'2	1'40
After 10 hours -	2'2	1'29

It will be observed from these tables that it is useless to prolong the boiling beyond a certain limit, after which the lye is almost without further action. Seven to eight hours' boiling answers for the lye-boils which precede the chemick, and four hours for those which follow.

Moreover, it will be seen that the lyes of the first boilings may be run away, as their alkali is almost exhausted, but that it is advantageous to collect the other lyes, which still contain 50 to 70 per cent. of the soda present in the original lye.

When the boiling is finished the gravity has not diminished, sometimes even it has increased, on account of the colouring principles dissolved in the lye. Fresh lyes are employed for those fabrics which are nearest to white, and old lyes are used for first boilings after the necessary quantity of soda has been added thereto to replace that which has been absorbed.

## EXAMPLES OF PROCESSES.

The following examples of processes have been experimented with by the author, and have yielded good results. He has made many experiments and seen many experiments made, some successful, some barren, and it is as a result of these experiments that he has been able to prescribe the processes detailed further on.

As to the other operations, such as washing, squeezing, chemicking, souring, he indicates those which he gives to the fabrics ; they may be modified according to the particular installation of each bleach works, and according to the methods adopted therein.

The washing in the keir is very important, above all after the caustic soda lye ; it frees the fabrics from a part of the soda. A single washing with 4,000 litres of water may do, but two are preferable. It is useful to have a reservoir tank in which the water is heated beforehand, because hot water cleanses the fabrics better. Two washings are prescribed after the lye-boils, the one with the roller washing machine, the other with the stocks or dash wheel. Although a single washing may often suffice, the author advises two, because the durability imparted to the fabrics will largely compensate for the extra labour.

*Fine White.—Cambric Muslins and Handkerchiefs.*

1. Steep from twelve to twenty-four hours ; wash in roller washing machine, in dash wheel, or stocks ; squeeze.
2. First lye-boil, six hours, Mather's keir ; caustic soda of 1.1° Baumé in summer and 1.4° Baumé in winter ; temperature, 116° C. ; wash in roller washing machine and in stocks.
3. Bleaching green, two days.
4. Sour, hydrochloric acid 0.5° Baumé ; temperature, 27° C. ; wash in stocks ; squeeze.

5. Second lye-boil, Mather's keir, same as previously.
6. Bleaching green, two days.
7. Third lye-boil, six hours, Mather's keir ; salt of soda,  $1.5^{\circ}$  Baumé ; temperature,  $116^{\circ}$  C. ; wash in roller washing machine and in stocks.
8. Bleaching green, two days.
9. Assortment 

{	First category—Chemick.
	Second category—Boil with salt of soda, $1.5^{\circ}$ Baumé, in small keirs.
10. First chemick, at  $0.20^{\circ}$  chlorometric strength ; temperature,  $25^{\circ}$  C. ; steep seven hours ; reel ; wash in stocks ; squeeze.
11. Sour, sulphuric acid of  $0.5^{\circ}$  Baumé ; temperature,  $27^{\circ}$  C. ; wash in stocks ; squeeze.
12. Scour with soap on rubbing boards.
13. Fourth lye-boil, four hours, Mather's keir, with carbonate of soda lye of  $2^{\circ}$  Baumé ; temperature,  $105^{\circ}$  C. ; wash in roller washing machine.
14. Bleaching green for two days.
15. Second chemick, at  $0.15^{\circ}$  chlorometric strength ; temperature,  $25^{\circ}$  C. ; steep seven hours ; reel ; wash in stocks ; squeeze.
16. Sour, sulphuric acid of  $0.5^{\circ}$  Baumé ; temperature,  $27^{\circ}$  C. ; wash in stocks ; squeeze.
17. Scour with soap on rubbing boards.
18. Fifth lye-boil, four hours, Mather's keir, with carbonate of soda lye of  $1.5^{\circ}$  Baumé ; temperature,  $105^{\circ}$  C. ; wash in roller washing machine ; squeeze.
19. Bleaching green, two days.
20. Third chemick, of  $0.10^{\circ}$  to  $0.15^{\circ}$  chlorometric strength ; temperature,  $25^{\circ}$  C. ; steep six hours ; reel ; wash in stocks ; squeeze.
21. Sour, sulphuric acid of  $0.5^{\circ}$  Baumé ; temperature,  $27^{\circ}$  C. ; wash in stocks ; squeeze.



22. Assortment { First category—Finish.  
 Second category—Fourth chemick, sour and finish.  
 Third category—Scour with soft soap in stocks or on rubbing boards, boil with carbonate of soda of  $1^{\circ}$  Baumé, fourth chemick, sour and finish.

23. Fourth chemick, at  $0.10^{\circ}$  chlorometric strength; temperature,  $20^{\circ}$  C.; steep four hours; wash in stocks; squeeze.

24. Sour, hydrochloric acid of  $0.25^{\circ}$  Baumé; temperature,  $27^{\circ}$  C.; wash in stocks; squeeze.

*Note I.*—A sour is the last operation before despatching to be finished.

*Note II.*—After the third chemick it is the duty of the workman entrusted with the assortment to decide what further operations are necessary to complete the bleaching. Exposure on the bleaching green will also be useful, provided always that the fabrics run no risk of being soiled whilst there. In any case the fabrics must be lye-boiled before the fourth chemick. As soon as this latter operation is done there is no need to resort to others.

*Household White.—Cambric Muslins and Handkerchiefs.*

1. Steep; wash; squeeze.
2. First lye-boil, six hours, Mather's keir, with caustic soda lye of  $1.5^{\circ}$  Baumé; temperature,  $116^{\circ}$  C.; wash in roller washing machine and stocks.
3. Bleaching green, two days.
4. Sour, hydrochloric acid of  $0.5^{\circ}$  Baumé; temperature,  $27^{\circ}$  C.; wash in stocks; squeeze.
5. Second lye-boil, Mather's keir, in the same conditions as the first.
6. Bleaching green, two days.

7. First chemick, of  $0.35^{\circ}$  chlorometric strength ; temperature,  $25^{\circ}$  C. ; steep five hours ; reel ; wash in stocks ; squeeze.

8. Sour, sulphuric acid of  $0.5^{\circ}$  Baumé ; temperature,  $27^{\circ}$  C. ; wash in stocks ; squeeze.

9. Scour with soap on rubbing boards.

10. Third lye-boil, four hours, Mather's keir ; carbonate of soda lye  $2^{\circ}$  Baumé, or salt of soda of  $1.5^{\circ}$  Baumé ; temperature of boiling,  $105^{\circ}$  C. ; wash in roller washing machine.

11. Bleaching green, two days.

12. Second chemick, of  $0.30^{\circ}$  chlorometric strength ; temperature,  $25^{\circ}$  C. ; steep five hours ; reel ; wash in stocks ; squeeze.

13. Sour, as after first chemick ; wash in stocks ; squeeze.

14. Assortment	{	First category—Finish.
		Second category—Chemick at $0.20^{\circ}$ chlorometric strength ; steep four hours ; sour and finish.
		Third category—Scour with soap and lye-boil with carbonate of soda at $2^{\circ}$ Baumé ; chemick at $0.2^{\circ}$ chlorometric strength ; steep four hours ; sour ; finish.

*Cholet white (blanc de Cholet).—Muslins and Handkerchiefs.*

1. Steep ; wash ; squeeze.

2. Boil ten hours with milk of lime in proportion of 10 per cent. of quicklime on weight of fabrics ; wash in roller washing machine or in stocks.

3. Sour at  $0.5^{\circ}$  Baumé ; temperature,  $27^{\circ}$  C. ; wash.

4. First lye-boil, six hours, Mather's keir ; caustic soda lye of  $1.4^{\circ}$  Baumé ; temperature,  $116^{\circ}$  C. ; wash in roller washing machine and in stocks.

5. Bleaching green, two or three days.

6. Second lye-boil, six hours, Mather's keir, with salt of

soda lye  $1\cdot5^{\circ}$  Baumé ; temperature,  $116^{\circ}$  C. ; wash in roller washing machine and in stocks.

7. Bleaching green, two days.

8. First chemick, of  $0\cdot25^{\circ}$  chlorometric strength ; temperature,  $25^{\circ}$  C. ; steep six hours ; reel ; wash in stocks ; squeeze.

9. Sour at  $0\cdot5^{\circ}$  Baumé ; temperature,  $27^{\circ}$  C. ; wash in stocks ; squeeze.

10. Scour with soap on rubbing boards.

11. Third lye-boil, four hours, Mather's keir, with salt of soda lye at  $1^{\circ}$  Baumé ; temperature,  $105^{\circ}$  C. ; wash.

12. Bleaching green, two days.

13. Second chemick, of  $0\cdot20^{\circ}$  chlorometric strength ; temperature,  $25^{\circ}$  C. ; steep six hours ; reel ; wash in stocks ; squeeze.

14. Sour, same as after first chemick ; wash ; squeeze.

15. Assortment	{	First category—Finish.
		Second category—Scour ; chemick ; sour ; finish.
		Third category—Scour ; lye-boil with salt of soda of $1^{\circ}$ Baumé ; sour and finish.

N.B.—The last chemick of  $0\cdot15^{\circ}$  chlorometric strength ; temperature,  $25^{\circ}$  C. ; steep five hours.

*Fine du Nord Linen and Irish Linen.*

1. Steep from twelve to twenty-four hours ; wash ; squeeze.

2. First lye-boil, six hours, Mather's keir, with caustic soda lye of  $1\cdot2^{\circ}$  Baumé ; temperature,  $116^{\circ}$  C. ; wash in roller washing machine and in stocks.

3. Bleaching green, four days.

4. Sour, hydrochloric acid of  $0\cdot5^{\circ}$  Baumé ; wash in stocks ; squeeze.

5. Second lye-boil, Mather's keir, same as first.

6. Bleaching green, four days.

7. Third lye-boil, six hours, Mather's keir, with salt of soda lye of  $2^{\circ}$  Baumé ; temperature,  $116^{\circ}$  C. ; wash in roller washing machine or in stocks.

8. Bleaching green, four days.

9. Assortment  $\left\{ \begin{array}{l} \text{First category—Chemick.} \\ \text{Second category—Lye-boil with salt of} \\ \text{soda lye of } 1.5^{\circ} \text{ Baumé.} \end{array} \right.$

10. First chemick, of  $0.20^{\circ}$  chlorometric strength ; temperature,  $25^{\circ}$  C. ; steep seven hours ; reel ; wash in stocks ; squeeze.

11. Sour, sulphuric acid  $0.5^{\circ}$  Baumé ; temperature,  $27^{\circ}$  C. ; wash in stocks ; squeeze.

12. Scour with soap on rubbing boards.

13. Fourth lye-boil, four hours, Mather's keir, with carbonate of soda lye of  $2.0^{\circ}$  Baumé ; temperature,  $105^{\circ}$  C. ; wash in roller washing machine.

14. Bleaching green, four days.

15. Second chemick, of  $0.15^{\circ}$  chlorometric strength ; temperature,  $25^{\circ}$  C. ; steep seven hours ; reel ; wash in stocks ; squeeze.

16. Sour, sulphuric acid of  $0.5^{\circ}$  Baumé ; temperature,  $27^{\circ}$  C. ; wash in stocks ; squeeze.

17. Scour with soap on rubbing boards.

18. Fifth lye-boil, four hours, Mather's keir, with carbonate of soda lye of  $1.5^{\circ}$  Baumé ; temperature,  $105^{\circ}$  C. ; wash in roller washing machine.

19. Bleaching green, four days.

20. Third chemick, of  $0.10^{\circ}$  chlorometric strength ; temperature,  $25^{\circ}$  C. ; steep six hours ; reel ; wash in stocks ; squeeze.

21. Sour, sulphuric acid of  $0.5^{\circ}$  Baumé ; temperature,  $27^{\circ}$  C. ; wash in stocks ; squeeze. Starting from here it is the duty of the workman entrusted with the assortment to decide the number of operations necessary to arrive at the proper



degree of whiteness, having due regard to the durability of the fabrics. It is therefore necessary to make a selection from the following operations.

22. Scour with soap on the rubbing boards.

23. Lye-boil with carbonate of soda lye of  $0.7^{\circ}$  to  $1.0^{\circ}$  Baumé.

24. Bleaching green, two days.

25. Scour or light lye-boil.

26. Chemick of  $0.10^{\circ}$  chlorometric strength ; temperature,  $25^{\circ}$  C. ; steep four hours ; wash in stocks.

27. Sour, hydrochloric acid of  $0.25^{\circ}$  Baumé ; temperature,  $20^{\circ}$  C. ; wash in stocks and wash wheels.

Finish.

*Remark I.*—Before the first chemick, in bad weather, it is very useful to give the fabrics a fourth lye-boil in Mather's keir, with salt of soda of  $2^{\circ}$  Baumé.

*Remark II.*—It must not be decided beforehand to give a certain number of lye-boilings and exposures on the bleaching green before the chemick, but to give the linen fabrics the number of lye-boils required to prepare them for the chemick. This depends on the nature of the fabrics and the season.

*Remark III.*—Irish linens demand a more decided white than du Nord linen. The treatment of the former commences with a lime-boil, followed by a hydrochloric acid sour. If the linens are woven with cream yarn they must receive a steep, followed by a wash, before being lime-boiled.

*Remark IV.*—Linen cloths are more difficult to bleach than handkerchiefs and fine linen, as they are more closely woven ; they must be treated with weaker lyes, etc., and these are repeated more often, care being taken that the washings are thorough, the soundness of the fabric being ascertained from time to time as the bleaching process progresses.

*Remark V.*—Heavy, coarse, tightly woven linen cloths are more easily attenuated than fine linens ; they must be

treated with weaker lyes, and it is prudent not to attempt to bleach them too far at the expense of soundness and durability.

*Remark VI.*—The process given indicates the maximum operations to be given in winter. In summer the number of lye-boils and their strength is diminished.

*Cottons, Piqués secs and Swanskin piqués.*

1. Boil six hours with milk of lime in proportion of 10 per cent. of lime on the weight of the fabrics ; wash in roller washing machine.

2. Sour, hydrochloric acid of  $0.5^{\circ}$  Baumé ; temperature,  $27^{\circ}$  C. ; wash in washing machine.

3. First lye-boil, seven hours, Mather's keir, with caustic soda lye of  $2.2^{\circ}$  Baumé ; temperature,  $116^{\circ}$  C. ; wash in keir only.

4. First chemick, of  $0.35^{\circ}$  chlorometric strength ; temperature,  $25^{\circ}$  C. ; steep six hours ; wash in roller washing machine.

5. Sour, hydrochloric and sulphuric acids mixed ; wash in roller washing machine.

6. Second lye-boil, six hours, Mather's keir, with salt of soda lye at  $2.2^{\circ}$  Baumé ; temperature,  $110^{\circ}$  C. ; wash in keir only.

7. Second chemick, of  $0.25^{\circ}$  chlorometric strength ; steep six hours ; wash in roller washing machine.

8. Sour, hydrochloric and sulphuric acids mixed ; wash in roller washing machine.

9. Third chemick, of  $0.15^{\circ}$  chlorometric strength ; temperature,  $20^{\circ}$  C. ; steep four hours ; wash in roller washing machine.

10. Sour, hydrochloric and sulphuric acids mixed ; wash twice in roller washing machine.

Finish.

*Quilts and Ribbons.*

Quilts and ribbons are more difficult to bleach than piqués. They are subjected to the same number of operations as piqués, but the lyes are of the density of  $3^{\circ}$  Baumé, instead of  $2.2^{\circ}$  Baumé. Between the second and third chemicks, those fabrics which require it are scoured on the rubbing boards, and are lye-boiled with soda lye at  $1.5^{\circ}$  Baumé.

*Calicoes, Trimming, Jaconets.*

These fabrics are less resistant than piqués. They must be subjected to more gentle operations.

1. Lye-boil with lime in proportion of 6 per cent. of lime on the weight of the fabrics; wash in dash wheels; squeeze.

2. Sour, hydrochloric acid of  $0.5^{\circ}$  Baumé; temperature,  $27^{\circ}$  C.; wash in dash wheels or in roller washing machine; squeeze.

3. First lye-boil, seven hours, Mather's keir, with caustic soda lye of  $8^{\circ}$  Baumé; temperature,  $116^{\circ}$  C.; wash in keir only.

4. First chemick, of  $0.25^{\circ}$  chlorometric strength; temperature,  $25^{\circ}$  C.; steep four hours; wash.

5. Sour, hydrochloric and sulphuric acids mixed; wash.

6. Second lye-boil, four to five hours, Mather's keir, with salt of soda lye of  $1.8^{\circ}$  Baumé; temperature,  $105^{\circ}$  C.; wash in keir only.

7. Second chemick, of  $0.20^{\circ}$  chlorometric strength; temperature,  $20^{\circ}$  C.; steep four hours; wash.

8. Sour, hydrochloric and sulphuric acids mixed; wash.

*Note.*—The fabrics ought to be white enough to be finished. If not, they are scoured with soap or lye-boiled, or are chemicked a third time with chemick of  $0.10^{\circ}$  chlorometric strength.

NEW IMPROVEMENTS IN THE CONSTRUCTION AND  
WORKING OF THE MATHER KEIR.

*Pressure.*—The principal improvement has been the constructing of the keirs of a stronger design, which enables them to be worked at a pressure of 40 lb. per square inch, instead of 15 lb., which was the maximum pressure they could work at formerly.

This increase of pressure has been found to give a very material reduction in the time necessary for boiling, say from eight hours at 15 lb. to six hours or even less at 40 lb., with an equally good effect.

*Door lifting.*—Another point is that the lifting arrangement for the door has been simplified, and now comprises a simple mechanical worm gear fixed to the front pillar of the keir, the back pillar having been done away with. This gear is driven by means of a rope from the shaft at the back of the keir which actuates the pump.

*Removal of air from the keir.*—When required, a special type of ejector is now fitted to the keirs for effecting a partial vacuum in them before the circulating liquor is admitted.

This removes the air very thoroughly, and prevents any risk of tendering the goods through a hot solution of caustic soda coming in contact with them in the presence of air.

*Circulation.*—The keirs are always fitted with an arrangement which enables the circulation of the liquor to be performed either upwards through the waggons, or downwards in the usual manner.

The upward circulation is specially valuable for washing in the keir after boiling.

*Washing.*—When the operation of boiling has been finished washing can be effected very thoroughly in the keir by means of cold water, owing to the manner in which it is introduced.



The valves are arranged for circulating upwards, and the cold water is connected to the suction side of the pump. The water then passes up through the waggons, and is warmed by

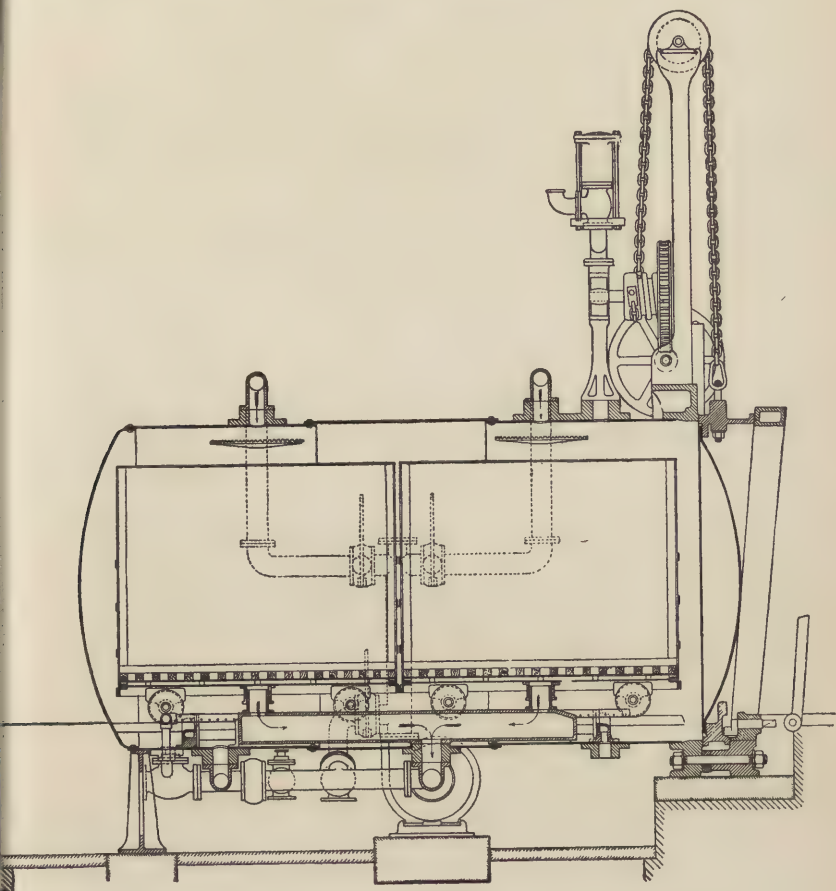


FIG. II.—Mather's Keir, Improved Pattern.

the hot liquor which remains in the cloth before it overflows the top of the waggons and comes in contact with the keir itself.

This manner of working has the advantage of preventing

the cold liquor coming immediately in contact with the body of the keir, and also of preventing the sudden formation of a vacuum, which might occur if cold water were introduced in a shower over the waggons while some steam remained in the keir, and this violent production of a vacuum might cause damage to the waggons.

*Heating of liquor.*—In some cases, where specially desired, an outside multi-tubular heater for the liquor has been adopted, but in most cases the former arrangement of a coil pipe and a set of perforated heating pipes in the bottom of the keir is preferred.

The enclosed plan shows a section through the keir, and gives particulars of the improved arrangement of raising and lowering the door.

The capacity of the keir, of course, depends upon the texture of the goods, but for ordinary cotton goods the capacity of the 12'0" or ordinary size of keir may be taken as approximately about 2,500 *kilogrammes*, say  $2\frac{1}{2}$  tons of cloth, and of the larger (16'0") as about 3,300 *kilogrammes*, say  $3\frac{1}{3}$  tons.

Another advantage possessed by the keir is that obtained by its mechanical arrangement, particularly as regards its capacity for continuous working. Owing to the rapid changing of the charges of cloth no time is lost, and the keir is never at a standstill. As soon as one charge has been treated, another charge of say  $2\frac{1}{2}$  tons or  $3\frac{1}{3}$  tons is ready to be sent to work, thus economising time and apparatus.

A further advantage offered, from a mechanical point of view, is the subdivision of the cloth into two separate lots in the waggons, each having its own connection to the pump and showering arrangement overhead. This, together with the energetic action of the pump, gives a powerful and positive circulation of the liquor, ensuring its coming in contact equally and thoroughly with every part of the cloth, and giving corresponding economy of time and chemicals.

*Single boil process.*—Another point to which we will draw attention is that in the majority of cases for bleaching cotton goods a single boil process is adopted, one treatment with caustic soda being found quite sufficient for the most perfect bottoming of cotton goods, whether they are intended for printing or finishing in the white state.

When bleaching black greys (doubliers) from the printing machine which are heavily charged with colour, it is sometimes found desirable to employ a double process, comprising a preliminary boil, followed by a soda-boil, and for this process the keir is equally suitable.

We have noticed a linear speed of saturating machine as 5,000 *metres* an hour ; this refers especially to linen goods, as calicoes can be saturated in similar machines at about double this speed, say 10,000 *metres* per hour for each piece through the machine, giving a total quantity of 20,000 *metres* saturated in one machine in one hour.

*Process for bleaching.*—The following process for cotton goods with the single caustic soda-boil is in use in many of the largest calico-printing, bleaching and finishing works in England and on the Continent.

Process for bleaching say  $2\frac{1}{2}$  tons of calico (say 2,500 *kilogrammes*) in the Mather keir, working at a pressure of 40 lb. per square inch.

*Wash* through roller washing machine, and

*Sour* continuously with acid at about  $2^{\circ}$  Twaddell, and allow to lie three to twelve hours.

*Wash* through roller washing machine, squeezing as dry as possible, and saturate with hot caustic soda at about  $2^{\circ}$  Twaddell.

Pile into keir waggons, run the waggons into the keir, close the door and lock the joint with the cam.

If the keir is fitted with an ejector turn steam on to this until a partial vacuum has been obtained.

Then admit the circulating liquor, which has been previously prepared in the mixing cisterns, and which comprises about—

60 lb. caustic soda, 70 per cent.

35 lb. rosin.

500 to 550 gallons of water.

This is drawn by the pump and delivered into the bottom of the waggons, flowing upwards through the cloth and driving out any air that may have remained in the folds.

When all the liquor is in the keir, turn steam on to the heating pipes and commence the circulation. The pressure is raised to 40 lb., and circulation is continued for about five or six hours at this pressure.

Then allow the pressure to fall to say 2 lb. per square inch and, if the water is of good quality, when the keir is two-thirds filled the discharge valve is opened, and the washing is continued as long as necessary.

Open the keir door, draw the waggons out, and rinse through roller washing machine.

Chemick at  $\frac{1}{4}^{\circ}$  to  $\frac{1}{2}^{\circ}$  Twaddell, and allow to lie for a few hours.

Wash and sour continuously at about  $2^{\circ}$  Twaddell, and allow to lie ; wash twice and squeeze.

#### TASSEL'S KEIR.

Tassel, a French engineer, has recently invented a keir which works under conditions analogous to Mather and Platt's (of Manchester) keir. Tassel's keir is made by the well-known firm of Ferdinand Dehaitre, Paris, and to the knowledge of the author it is used in several bleach works, where it gives entire satisfaction.

This keir is intended for the lye-boiling of fabrics in an atmosphere of steam, that is to say, out of contact with air, and in certain liquids. It is particularly intended for lye-



boiling with caustic soda, because it allows of the perfect washing of the fabrics both in the hot and in the cold, without taking them out of the keir.

By a peculiar arrangement, it is only necessary to use but a small quantity of liquid, about 1,000 *litres*. Consequently, the use of the keir is very economical from the point of view of outlay on chemicals.

The plant consists of two keirs, one fitting into the other. The outside keir is provided with a lid closed by bolts and nuts. The inside keir is portable, and may be taken out of the larger keir and run on to a special truck. A centrifugal pump keeps up perfect circulation.

When being charged the portable keir is placed on a truck and filled with fabrics in coils or bands, either directly or after being saturated in a special machine. Owing to the circular form of the keir, the fabrics can be spread in it very regularly, a condition absolutely essential to the regularity of the lye-boiling, which can hardly be obtained with horizontal plant.

When at work the centrifugal pump circulates the liquid. This, whilst forming a layer above the fabrics so as to prevent them from coming in direct contact with the steam, does not do so, however, without traversing the mass, which not only effects a perfectly regular washing, but it does so without using more than the quantity of water strictly necessary for the working of the pump and the boiling.

The liquid only rises to a very small height between the keirs, and all the free space is filled by steam. It will be understood that under these conditions it is necessary for the inside keir to be perfectly tight, a result easily obtained with this kind of keir, and only with very great difficulty in a convex-sided waggon, the faces of which are joined together by lead joints, which the caustic soda attacks in the end.

In order to wash with hot water, a jet of boiling water is

pumped in so as to fill the whole of the outside keir ; the strength of the liquid is thus reduced. The liquid is then run off, leaving only the quantity necessary to work the pump. By repeating this operation a second time the lye is so reduced that the air has no injurious action on the fibre.

Washing in the cold is effected through the lower part of the inside keir. By a suitable manipulation of valves the circulation is reversed. The cold water pumped from the main is circulated under the mass of the fabrics, passes through them, filling the portable keir, and running away at the top into the intervening space escapes through an exit tap. In twenty minutes the fabrics are perfectly lye-boiled, an operation which cannot be effected with the ordinary machines in less than two hours.

By using two portable keirs per fixed keir they may be charged during the working of the keir ; the production is thus doubled.

When the amount of bleached fabrics does not exceed 1,500 *kilogrammes* (say 3,375 lb.) daily, it is not necessary to remove the portable keir. It is left in the fixed keir and the keir is charged and discharged on the spot as in the case of an ordinary keir. An economy is thus effected in the cost of the first laying down of plant and in the price of the washing machines.

With two movable keirs 3,000 *kilogrammes* (say 6,750 lb.) may be treated. In fact a portable keir, charged beforehand, may be brought into the fixed keir first thing in the morning, then the goods boiled for four hours, and washed in the keir for one hour and a half.

During the time this is going on a second portable keir is charged beforehand, which immediately replaces the first, and the operations thus go on continuously.

The arrangements for handling movable keirs may be rendered more easy by means of a crane revolving on a pivot

and used for several keirs, and a service of waggons carrying the portable keirs to the washing machines from the lye-boiling and to the saturating machines for the lye-boiling.

As is customary in the Irish bleach works, the keir is fixed so as not to project more than about 1 *metre* above ground. The movable keir having a depth of 1.77 *metre* (say 69 inches) for 1,500 *kilogrammes* (say 3,375 lb.), it can easily be manipulated in buildings of average height. In larger establishments the keirs are increased in diameter but not in height.

The inside keir is indispensable for the safe use of caustic soda in concentrated solution.

In fact, in an ordinary keir, containing at least 7,000 *litres* (say 1,540 gallons) of water for 1,500 *kilogrammes* (say 3,375 lb.) of fabrics, about 18 *kilogrammes* of caustic soda per cubic *metre* (say 18 lb. per 100 gallons) would be required—126 *kilogrammes* (say 2½ cwt.) of alkali per operation, which would come to the excessive cost of 35 francs or 28s. per operation.

With Tassel's plant with interior keir 1,000 to 1,500 *litres* (say 220 to 330 gallons) only of liquid are required, because all that is necessary is for the fabrics to be prevented from coming in contact with the steam, and as they are piled closely a small quantity of liquid suffices to protect them. Only enough liquid to work the pump, and no more, is left in the intervening space. This small quantity of liquid contains on an average about 50 *kilogrammes* (say 1 cwt.) of caustic soda, and forms a concentrated liquid capable of yielding a good and economical lye-boil costing about 6 francs (say 4s. 9d.).

Moreover, as caustic soda is attended with the risk of damaging the textile fabrics unless prevented from coming in contact with air, it is necessary at the end of a lye-boil to bring the fabrics from a temperature of 110° C. to the ordinary temperature. This last operation can only be done with the interior keir, the arrangement of which alone allows of running

off the liquid whilst preserving the fabrics from contact with the air. The manner of performing the washing has been already indicated.

Summing up, by using Tassel's keir concentrated caustic soda lyes may be employed without injuring the fabrics, and thus perfect bleaching is rapidly and economically obtained with a less costly plant than that involved by the horizontal machines at present in use, and with greater facilities for making joints.



## CHAPTER VI.

### SOAP.<sup>1</sup>

*Short Description of Soap Manufacture—Action of Soap in Bleaching—Manufacture of Rosin Soap—Manufacture of Olein Soap—Use of White Marseilles Soap—Comparative Cost of the three Kinds of Soap—Testing Soap—Quality and Quantity of Soaps to use in the Lye—Soap Lyes or Scalds—Soap Scouring Stocks—Soap Scouring Rubbing Machine.*

*Short Description of Soap Manufacture.*—Soap is the result of the combination of a vegetable or animal oil or a fat with an alkali soda or potash.

The typical soap—that from which all others have been derived—is Marseilles soap, consisting of olive oil and soda lye, with a little tallow to increase the hardness.

The manufacture of soap involves quite a host of operations requiring great skill and experience to secure good results, and which, leaving on one side the details of the working manipulations, may be reduced to the following : the quantity of lye corresponding to the oil to be operated on is run into a pan and boiled, and the whole oil run in at once ; the heat is kept up, but not too great a heat, running in from time to time a fresh quantity of lye into the pan. This first operation is known as saponification.

<sup>1</sup> For full particulars in regard to soap manufacture see special chapter on Textile Soaps in Hurst's *Treatise on Soap Manufacture*, published by Scott, Greenwood & Co., the publishers of this volume.

In the second stage the spent lye is run off by means of a pipe fixed to the bottom of the pan, and the boiling is continued, fresh lye being run in all the time. This is the soap boiling proper, which is finished when the solidified lye crumbles to powder between the finger and thumb.

The purification comes afterwards ; the soap is finished, but it is impure. It is reboiled with the addition of weaker alkaline lyes, or with brisk agitation of the paste, which is kept in a semi-fluid state. The heavier foreign matters settle down at the bottom, after which it only remains to run the soap into the frames. The marbled soap so frequently met with in commerce has been mixed with sulphate of iron, green copperas. It contains 30 to 40 per cent. of water. White soap contains 40 to 50 per cent. of water.

*Action of Soap.*—Soap is very extensively used in bleaching. On the one hand it acts as a solvent of the resinous matter, whilst on the other hand it acts mechanically by facilitating the expulsion of the impurities in the fabric. The soapy waters convert the impurities in the fabric into more or less soluble compounds, which only require to be removed by washing. Soap in lathering renders these impurities more smooth, more gliding, and when the fabric is rubbed they emerge more easily. Marseilles soap, black soap, olein soap, rosin soap are used in bleaching. It is advisable for large bleach works to make their own soap. Rosin soap and olein soap give very good results, and their manufacture will now be described.

*Manufacture of Rosin Soap.*—Rosin soap is made in a pan made of iron plate and heated by a steam coil. The following are the proportions used :—

Rosin	-	-	-	-	-	100 lb.
Caustic Soda, 110° Descroizilles						25 „
Water	-	-	-	-	-	100 gallons.

The water and the caustic soda are run into the pan, and brought to the boil so as to dissolve the soda. The muck,

which floats to the top in the form of a froth, is removed by a skimmer. The rosin is then run in, stirring all the while, so as to prevent it from settling at the bottom. The heat is kept up quite gently (simmering) for four or five hours. To know whether a good result has been got, run a little of it into a glass and observe whether it be transparent, or whether it be curdy. When pouring slowly the contents of the glass should string. It should be greasy to the touch.

*Manufacture of Olein Soap.*—Distilled olein is used. This soap is made like rosin soap. The proportions are the following :—

Olein	-	-	-	-	-	75 lb.
Caustic Soda, 110° Descroizilles						15 „
Water	-	-	-	-	-	100 gallons.

Olein contains petroleum and hydro-carbons, which do not make soap, or at least do not lather, but it would not appear that this is any detriment in the bleaching. It contains iron, which gives to it a blackish colour. This is due to the fact that manufacturers allow it to settle and cool in iron receptacles, which it dissolves. It also dissolves lead very freely, and this lead imparts to the fabrics a greyish tint, which cannot be got rid of afterwards. This fault is well known to silk and wool manufacturers. Olein contains a greater or less amount of stearine; by allowing the olein to settle the stearine falls to the bottom; stearine lathers. In order to make a good olein soap it is necessary to start upon a clear sample of yellow olein, limpid and not cloudy.

*Use of White Marseilles Soap.*—Rosin soap, olein soap and white Marseilles soap are the three varieties of soap preferred for bleaching.

The soap may be cut up and dissolved in the water before dissolving the soda. It is very convenient in bleach works to have a solution of white soap prepared beforehand. The soap is dissolved in a special pan for the purpose, and is

drawn off by a tap when required to be added to the lye, or for any other purpose. The proportions are :—

Soap	-	-	-	-	-	100 lb.
Water	-	-	-	-	-	100 gallons.

Before drawing the soap it must be well mixed, as the soap falls to the bottom. This mixing is very well done by a steam coil placed in the bottom of the pan. The boiling agitates the mass, and renders it homogeneous.

Should the water be calcareous, before dissolving the soap a little caustic soda is added to precipitate lime compounds, because the lime in solution would transform part of the soap into a lime soap insoluble in water, and which would appear in the form of curds.

### *Comparative Cost of different Soaps.*

The cost per *litre* is got by supposing the quantities indicated are dissolved in enough water to make 1,000 *litres*.

#### WHITE SOAP.

100 kilogrammes of soap at 75 francs the 100 kilogrammes	-	=	75'00 francs.
Price <sup>1</sup> of a litre $\frac{75}{1000}$	- - - - -	=	0'75 „

#### OLEIN SOAP.

75 kilogrammes of olein at 50 francs the 100 kilogrammes	-	=	37'50 francs.
15 kilogrammes of caustic soda at 32 francs the 100 kilogrammes	=	4'80 „	
		<hr/>	
		42'30 „	
Price <sup>1</sup> of a litre $\frac{42'30}{1000}$	- - - - -	=	0'042 „

#### ROSIN SOAP.

100 kilogrammes of rosin at 15 francs the 100 kilogrammes	-	=	15'00 francs.
25 kilogrammes of caustic soda at 32 francs the 100 kilogrammes	=	8'00 „	
		<hr/>	
		23'00 „	
Price <sup>1</sup> of a litre $\frac{23'00}{1000}$	- - - - -	=	0'023 „

<sup>1</sup> In other words, the cost of equal volumes of the dissolved soap is in the ratio of 75, 42 and 23.

The *Irish Bleachers' Guide Book* gives the following recipes for making soaps :—

*Manufacture of White Soap.*—Make a concentrated caustic soda lye and fill the pan to about a third with it. Heat almost to boiling, and add the tallow. Add it in such quantity that, once dissolved, a creamy consistency is obtained ; stir gently, keeping up a slow fire. Boil for about four days, and stop when the soap is of the requisite consistency, but do not boil too much, for the soap will become too thick and stick to the sides of the pan.

*Another Method.*—Put about 300 lb. of tallow in the pan and run in  $22\frac{1}{2}$  gallons of strong caustic lye, keeping up a gentle heat. Boil for four days and ladle into the frames. The lye may be changed two or three times by running away the liquid portion after cooling the pan. This method yields a very strong soap, but for bleaching one lye is enough ; 600 to 700 kilogrammes of tallow yield a ton of soap.

*Rosin Soap.*—Boil the tallow and the soda as before, then add as much pulverised rosin as will make one fourth of the tallow used, and mix the whole with lye, stirring with a rake. The soap is finished when it becomes solid on cooling, or else when, mixed with a little water, it does not leave a resinous varnish on the skin. Its colour may be deepened by the addition of a little palm oil.

*Soft Soap.*—Whale, cod, seal, olive, linseed and palm are the oils used, with a little tallow.

Run a portion of the oil into the pan, bring almost to the boil, then add a weak lye. Bring to the boil and add lye and oil until you have introduced the desired quantity.

When you have obtained regular ebullition with good agitation, add a little stronger lye until complete saponification is effected. When the curds have disappeared, and the paste ceases to “bite” the tongue, and spread on a glass plate it presents the requisite consistency, and taken between the



fingers it is perfectly smooth, then the soap is finished. Twenty-two *kilogrammes* (say 50 lb.) of oil and 8 *kilogrammes* (say 18 lb.) of caustic soda of 110° Descroizilles diluted with water so as to mark 6° to 7° Baumé will yield 50 to 55 *kilogrammes* (say 1 cwt. to 1¼ cwt.) of soft soap. When potash is used instead of soda a softer soap is obtained.

### *Soap Testing.*

It is very important that the bleacher should satisfy himself as to the quality of the soap which he uses. It may be had on the market at all prices, but owing to the large quantity of water and impurities it is advisable to pay a good price and get a good article.

The systematic analysis of soaps is too complicated to be employed by the bleacher. The following method will enable him to make an approximate relative valuation of different soaps :—

Quicklime is dissolved in water, and after decantation the clear liquid is drawn off and used as the test liquid. Ten *grammes* of each sample of soap to be tested are then weighed out, and each of these samples is dissolved in distilled water and the bulk made up to a *litre*. Then 10 c.c. of the clear lime water are run into a flask of about 100 c.c. capacity. A burette graduated in cubic *centimetres* and tenths of cubic *centimetres* is filled up to zero with the solution of the soap to be tested. The soap liquor is then run in drop by drop into the lime water, and the whole is agitated from time to time to see if there be a persistent froth, and the reading is taken when this occurs. The number of cubic *centimetres* is noted and the process is repeated on the remainder of the samples to be tested. The soap is first of all converted by the lime into a lime soap, and the lather only appears when this reaction is complete.

It follows therefore that the smaller the quantity there is required to be run in to saturate the lime the richer the soap in question is in fatty acids. If in testing three samples of soap the operator has run in, for example, 60 c.c. of the first;

40 c.c. of the second and 30 c.c. of the third, the conclusion would be that the value of these soaps are in the ratio  $\frac{1}{60}, \frac{1}{40}, \frac{1}{30}$ , and if the first soap cost 30 francs the 100 *kilogrammes*, the second should cost 45 francs and the third 60 francs the 100 *kilogrammes*.

The practical man can very often determine the quality of a soap by noticing how it lathers.

*Quality and Quantity of Soap to use in Lyes.*

It is advantageous to add a little soap to the lyes because soap emulsifies the substances dissolved by the soda and facilitates their expulsion from the fabrics. Soap may be dispensed with in the first lye; the substances to be dissolved being on the surface are easily removed by the lye. But in proportion as the fabrics begin to bleach, the lye ought to penetrate more intimately into the fibre, so as to dissolve all the substances which have resisted the first boiling; thus the action of the soap helps that of the lye.

Provided that the rosin soap be well made, it may be used in all the boilings, but if the rosin has not been well saponified it is deposited on the fabrics and soils them. This necessitates energetic boiling to remove the stains; acids also cause them to disappear. Rosin soap is yellow, and if the fabrics be not sufficiently washed they retain this tint, and are not so bright as if they had been treated with white soap.

The same remarks apply to olein soap, which has a brown colour. There is no risk of spotting, but it leaves a yellow tint behind on the fabrics. In the manufacture of olein soap bright yellow olein ought to be chosen, not dark.

Marseilles soap is the best for conferring a bright tint to the fabrics, but its price is very high, and it is only used in the lyes and washings which terminate the bleaching process.

The following would be a rational and judicious use of the different soaps :—

Rosin soap for lyes before chemick.

Olein soap for lyes intercalated between the chemicks.

White soap for the last lye-boil or the last soaping.

The quantity of soap for each lye is not fixed ; a good proportion is to run in 30 to 35 *litres* of liquid soap (say 3 to  $3\frac{1}{2}$  gallons per 100 gallons), made as indicated on p. 88, for every cubic *metre* of lye. This corresponds to 3 *kilogrammes* of Marseilles soap per cubic *metre* of lye (say 3 lb. per 100 gallons). The proportions by weight are 500 to 600 *grammes* of soap for 100 *kilogrammes* of fabric (say 1 lb. to  $1\frac{1}{4}$  lb. per cwt.).

*Soap Lyes or Scalds.*

When fabrics are almost white they may with advantage be boiled with soap before the last chemick, or even after it, before being sent to be finished. The author recommends olein soap, but preferably Marseilles soap. Good proportions are 5 to 6 *kilogrammes* of soap per cubic *metre* (5 to 6 lb. per 100 gallons), which is first of all boiled with 2 *kilogrammes* (say 2 lb. per 100 gallons) of soda crystals. If completely bleached goods be put in the soap-boil care must be taken to have everything right. The bottom of the vat should be frequently inspected ; it is there that the muck and dirt accumulates. Boiling brings it all up, and the goods are consequently soiled.

The temperature of the soap bath is maintained between  $75^{\circ}$  and  $80^{\circ}$  C. If too high a heat be used there is danger of yellowing the goods.

In those bleach works where boiling with soap is the last operation before finishing, the soap bath is sometimes coloured with a little indigo blue. The goods are then washed, but they retain a very persistent blue cast. The only thing to fear in this process is that the fabrics, retaining a little soap, may yellow in the shop.

The author would, however, recommend as a final operation a soap-boil instead of a sour in those bleach works

where the washing machines are not so perfect as not to leave a trace of acid. When the coarse sheeting of the Nord or of Normandy is being treated it is very difficult to remove all traces of acid by washing. A soap-boil as a last operation presents no such difficulty.

Moreover, it is customary to boil the fabrics with soap before putting them through the lyes which follow the chemick. But this is an operation which there is a tendency to suppress, because it is rather costly in labour and in soap. It is far better to pass the goods to the fulling mill or the dash mill; the expense of soap is the same, and its action is more energetic.

#### *Soap Scouring Stocks.*

This machine comprises :—

(1) A wooden tub mounted on a pivot and rollers and girdled in its lower part by a toothed collar. A pinion gearing into this collar imparts to the keir a circular motion causing it to make one and a half to two revolutions a minute.

(2) A series of wooden stocks arranged in the same line of action, along the axis of the tub, and which as they successively fall scour the fabrics. They are worked by cams mounted on a horizontal shaft and arranged in such a manner that the wooden stocks fall one after the other. This shaft makes forty revolutions a minute; in this way each stock strikes the fabrics forty times a minute. Each stock weighs 6 to 10 *kilogrammes* (say 13 to 22 lb.).

By means of a special arrangement all the stocks may be kept hoisted up during stopping time. A steam pipe in the centre heats the soap bath, and keeps the temperature about 60° C. during the operation.

Olein soap answers very well—fifty *litres* of olein soap per cubic *metre* of water. The trough is about half filled, say to a height of about 16 inches. The fabrics should not be piled too high up, because the action of the stocks will not

affect those at the bottom. Each batch is operated on from three quarters of an hour to one hour. The fabrics are then placed on a perforated wooden platform, underneath which is a soapy water reservoir. This soapy water is used in a subsequent operation with the addition of fresh soap to the bath.

The washing of fabrics in the stocks with soap answers very well for delicate fabrics, which it is to be feared would be injured on the rubbing boards. There is not much risk of danger in the stocks if they be kept in good condition.

*Soap Rubbing Board Washing Machine.*

The principle of this machine is to cause the fabrics impregnated with soap to pass between two corrugated wooden boards, one of which is fixed, whilst the other has a to-and-fro motion.

The upper board is propelled by a shaft attached to a crank, and the to-and-fro movement of the board rolls the fabrics first one way and then the other. The fabrics dip into a wrought-iron trough filled with soapy water. The fabrics are drawn by the rollers in front of the scrubbing boards; the traction speed is 0.60 *metre* to 0.80 *metre* (say 2 to 2½ feet) per minute. The shaft which imparts the to-and-fro motion to the boards makes sixty-five turns per minute. The boards are made of beech wood and are in two parts. The channeled portion is replaced when worn. The corrugations should be well rounded so as not to cut. The rubbing boards should be often inspected to see whether the grooves do not present any rough surfaces, asperities or unevenness which would destroy the fabrics.

The boards of the rubbing board machines with troughs are coupled together two and two, and the gutters inclined at an angle of 45°. The gutters of the upper board are inclined in an inverse sense to those of the lower board.

Rosin soap or olein soap is used; white soap would be too



dear. Fifty *litres* of soap are used per cubic *metre* of water (say 5 gallons per 100 gallons), and 2 *kilogrammes* of carbonate of soda. A steam pipe placed below the false bottom keeps the temperature up to 70° C. Once or twice daily 20 *litres* of soap are added per cubic *metre* of water (say 2 gallons per 100 gallons) to replace that which has been used up by the fabrics. The same soap liquor, strengthened as it becomes exhausted, lasts several times. It is renewed when too dirty.

The fabrics are passed through the rubbing boards before the lye-boil between the chemicks. This operation softens the fabrics, opens the fibres of the yarn, and exposes all their parts to the action of the bleaching agents, or to that of the atmosphere when exposed on the bleaching green. There need be no fear that the rubbing boards will injure the fabrics. Very fine goods are passed through them without sustaining any injury, provided that they are drawn gradually through between the rubbing boards in a uniformly regular manner, which can be obtained by well regulating the machine. Fine narrow fabrics are doubled, or two are passed at the same time. Special care should be taken in regard to the consecutive joining together of the pieces so as not to draw the knots too tight, because the rubbing boards would cut the fabrics at that point.

The number of times that it will be necessary to pass the fabrics through this machine cannot be determined beforehand ; it depends on the quality of the goods, and the degree of whiteness aimed at. For a fine white, tissues with a bright foundation are passed two or three times, but in the case of a dark foundation they must be passed four to six times, following each wash on the rubbing board machine with a lye-boil. The passage through the rubbing boards shrinks and lengthens the fabrics ; they must be stretched in the direction of their width in finishing.

## CHAPTER VII.

### BLEACHING ON GRASS OR ON THE BLEACHING GREEN OR LAWN.

1. *The bleaching action of exposure on a grass lawn or green—*
2. *Methods of spreading out on the bleaching green—*
3. *Precautions to be taken—*
4. *Arrangements and laying out of the bleaching green—*
5. *Watering—*
6. *The necessity for bleaching on the green.*

#### I. THE BLEACHING ACTION OF EXPOSURE ON THE BLEACHING GREEN.

FOUR elements act concurrently in the bleaching of fabrics exposed on the bleaching green, *viz.*, (1) Light, (2) Air, (3) Moisture, (4) The nature of the grass.

The most energetic bleaching agent is light, more especially sunlight. Fabrics bleach more rapidly when exposed on a sunny day than in dull weather, and better by day than by night.

Accordingly, when fabrics, woven or spun in part of coloured materials which are to be preserved intact, have to be bleached, they must not be exposed to direct sunlight. In summer they are lifted during the day or covered with other fabrics. They are only exposed during the morning, the evening and the night.

The bleacher must ascertain the resistance of the colour to light, and withdraw it at the proper time. The state of the atmosphere has a wonderful influence. Dry weather is not favourable; no more is rainy weather. Slightly moist weather, like that when the dew falls in the morning, suits

best. The bleacher cannot alter the state of the weather, but what has been said explains why the climate of certain countries is more favourable for bleaching than others. Ireland, so famous for its white linen, is endowed with a temperate climate and moist, uniform temperature. It owes these advantages to the sea and to the flow of the Gulf stream along its coasts. Brittany, in France, possesses similar advantages.

Finally, plants also play their part. In fact, if instead of spreading the fabrics on the green they be hung upon lines or cords, they do not bleach nearly so well. We do not know exactly how grass assists in bleaching ; it is in all probability due to the oxygen and carbonic acid which they disengage, as well as to the moisture which they yield to the fabrics.

Summing up, the bleaching action of grass exposure is very probably due to oxygen, but above all to ozone, which is oxygen in a particularly active state. Light, heat and moisture assist either in the transformation of oxygen into ozone, or to cause it to penetrate more intimately into the tissues of the fabric.

It is necessary to remark, however, that the oxidising action of grass bleaching has not only the effect of transforming coloured matters into colourless products, but it also transforms them into substances more easily dissolved by lyes. Suppose, for example, two lots of fabrics be taken, of which one only has been exposed on grass, and that they are washed separately, it will be seen when the boiling is finished that the lye of the lot exposed on the grass is charged to a much greater extent than the lye of the other lot, thus proving that its dissolving action is much more considerable.

## 2. METHOD OF SPREADING.

The fabrics are transferred either in waggons or on men's backs to the place where they are to be spread out. A workman takes hold of the sheet by one end and draws it out so

that it is extended to the whole of its length. Then the piece, held at both extremities, is untwisted and fixed in such a manner that it is thoroughly spread out. In the case of delicate fabrics, such as handkerchiefs or cambrics, care must be taken not to stretch them too much, for fear of breaking the selvage. If the piece be very long, a workman is placed in the middle to support it and prevent it being too much stretched. Sometimes it is preferred not to spread out the piece throughout all its length; it is refolded back upon itself, and the second part is spread alongside the first.

Coarse sheetings are fixed by pegs at their extremities so as to hinder them from rolling with the wind. Delicate sheets must not be fixed, as the wind would tear them.

Sometimes the pieces are kept stretched by wooden pins attached to cords at different intervals. Independent of the risk of tearing the goods, this complicated method is rarely employed in consequence of the heavy working expenses which it entails.

Coarse sheetings remain on the bleaching green four or five days; light fabrics two days. This would appear to be the most suitable length of time. But bleachers are often guided in this respect by the extent of their bleaching green and by the progress made in the bleach works.

### 3. PRECAUTIONS.

The wind rolls light fabrics into the form of cords or ropes. In such a case, if possible, they should be spread out again. It is a rather costly piece of handiwork, but it is money well spent, because the fabrics thus rolled up do not benefit by any further exposure on the grass.

The fabrics are often soiled by stormy rains spreading over them the dust carried along by the rain. The fabrics act like a sieve, allowing the water to pass through whilst retaining the dust. They are also often soiled by the wet,

muddy ground. These spots are difficult to remove, especially from light cross-warped fabrics. They must be washed before the mud dries; sometimes soaping is necessary, or even hand rubbing with a brush.

The further the bleaching process is advanced the more injurious are these spots. The best remedy is to prevent them from occurring.

Preference should therefore be given to the green best covered with sward for the bleaching of fabrics already well advanced to whiteness. If bad weather be feared they should be taken in from the bleaching green. Coarse sheetings should be hung up on pegs; water and dust will run down and not soil them. Fabrics soiled in this manner are not treated with lye without previous washing, because the lye at a high temperature would bake the mud and it would then be still more difficult to remove afterwards.

The effects of rain are not always identical in every instance. They vary according to the direction of the wind. The bleacher ought therefore to carefully observe the injurious effects of rain and make his arrangements accordingly to prevent them.

#### 4. ARRANGEMENT AND LAYING OUT OF BLEACHING GREENS.

Lawns intended for bleaching greens ought to receive special attention. They ought to have a good sward, because fabrics exposed on the naked earth are soiled with mud. They ought to be mown often, for light fabrics, spread upon long grass, soon roll up and do not bleach. The ground ought to be slightly inclined, with a uniform slope, or arched, in such a manner that the water easily runs away; if not it will remain in puddles, and thus cause mud spots. Moreover, in winter the fabrics will be frozen to the grass, and in detaching them carelessly will be torn.



Plants, the flowers of which soil the fabrics, must be weeded out. Gravel and pebbles must be removed. The fabrics rolled by the wind retain these in their folds, and when they are passed through the washing machines are the cause of accidents.

The bleaching greens are crossed by roads along which the fabrics to be bleached are brought close to the spot on which they are to be spread. Along the sides of the road wooden frames or stone tables are placed to receive the fabrics. If wooden frames be used care must be taken that the heads of nails do not project, otherwise they would soil the fabrics with rust and tear them.

Workmen should not walk on the fabrics, especially with shoes or clogs with nails. This is a cause of tearing and spots of iron rust.

When dealing with strong sheeting, like that of Normandy, difficult to tear, lines of posts are fixed into the bleaching green, about 3 feet 3 inches to 4 feet in height and about 10 feet apart. The distance between one row and another is a little greater than the width of the sheets to be spread out. These posts are used to raise the pieces in rainy weather, so as to prevent them being soiled by the dust of the atmosphere or the mud of the ground. At the end of each row of large posts, two posts ten inches high are placed, to which the piece of fabric is attached by its four corners, so as to keep it well spread on the grass.

##### 5. WATERING.

In some bleach works the fabrics laid on the green are watered. This is a costly piece of manual labour, and requires a special arrangement of small streams of water. The greens are intersected by a series of small parallel streams, 20 to 25 yards apart. The pieces are spread out in the intervening spaces, and a workman, provided with a rose of a special

form, projects the water, which falls in the form of a shower of rain on the fabrics. This is a highly beneficial operation, because when the fabrics are dry they bleach to a much smaller extent than when they are moist.

Moreover, when light fabrics are spread on the green, the slightest wind causes them to roll, whilst should they be moist they remain spread out much better.

An expert workman can water in an hour a surface of over 3,000 square yards. The work can be done by boys.

The author has seen a special form of instrument for watering employed with success. It consists of a piece of wood  $7\frac{1}{2}$  feet long, of which one part is scooped out in the form of an elongated spoon, whilst the other contracted part serves as a channel. The worker manipulates quickly the turn of the wrist to project the water.

#### 6. NECESSITY FOR EXPOSURE ON THE BLEACHING GREEN.

Cotton fabrics are generally bleached without exposure on the green; but up to the present time no means has yet been discovered by which this operation may be dispensed with in the case of linen.

The method used by Dr. O. Fröhlich for bleaching skeins of linen yarn by means of ozone, and thus dispensing with grass bleaching, is given in the last chapter of this volume. The author does not know whether, if it were likewise applied to the bleaching of fabrics, grass bleaching might be dispensed with. In any case, with the processes in common use, if the fabrics be not exposed on the green, they remain yellow, and this tint becomes more apparent when the fabrics have been warehoused for some time.

## CHAPTER VIII.

### CHEMICKING.

REMARKS ON CHLORIDES AND THEIR DECOLOURISING ACTION.

CHEMICKING CISTERNS.—*Wooden Troughs—Stone Cisterns.*

CHEMICKING.—DIFFERENT METHODS.—*Packing the Fabrics in the Cistern with the Feet—Packing with a Stick—Packing in the Dry—Chemicking with the Washing Machine—Reeling.*

STRENGTH, ETC.—*Temperature and Duration of Chemicks—Preparation of the Fabrics to be Chemicked—Quantity of Chlorine used on the Fabrics and Absorbed by them—Preparation of Chemicks.*

REMARKS ON CHLORIDES AND THEIR DECOLOURISING ACTION.

A GENERAL idea is given in Chapters XIV. and XV. of the nature of chlorine and its compounds, its bleaching action and the properties of the different chlorides, their mode of production, and the methods used to determine their strength. They may be summarised as follows:—

The accepted opinion is that chlorine, in bleaching, oxidises the colouring principles of the fabrics, and combines with hydrogen to form hydrochloric acid.

The chemicks ought to be weak enough and to last for such a short time as only to attack the colouring principle and not the fabric itself by transforming its cellulose into oxy-cellulose or into hydrocellulose.

The decolourising chlorides most usually employed are chloride of lime and chloride of soda.<sup>1</sup> When chloride of lime is used care must be taken to see that the liquid is perfectly clear and that all the lime has settled out well. If any lime remain in suspension the fabrics will be damaged. Chloride of soda<sup>1</sup> is higher in price than chloride of lime, but it is more safe and does not impair the strength of the fabrics to the same extent. It is used for fine goods.

The chlorides are easily decomposable substances, especially when neutral; an excess of alkali imparts stability to them. In the neutral state their bleaching power is very energetic, but its action is moderated by an excess of alkali. It is not advisable to use chlorides the bleaching power of which is too energetic, because the chlorine would only bleach the surface of the yarn without penetrating into the interior. It is also to be feared that it might attack not only the colouring principle, but also the fibre itself. On the other hand, the chloride must not, in consequence of an excess of alkali, be too slow in bleaching, because the fabrics would run the risk of being destroyed by remaining too long in the chemick. In the case of clear liquid chloride of lime, the excess of lime is almost constant and corresponds to the small amount of lime soluble in the chloride. But as regards chloride of soda, the excess of soda, on account of its great solubility, may be very considerable. Experience has proved that the chloride of soda most suitable for bleaching should only contain a small excess of soda. A chloride of 15° chlorometric strength ought to contain 3 to 4 *grammes* per *litre* of caustic soda NaHO in excess.

The chlorometric degrees used to indicate the strength of the chemicks are French chlorometric degrees. They express the number of *litres* or fractions of *litres* of gaseous chlorine contained in one *litre* of chemick. The methods of treating or

<sup>1</sup> By chloride of soda, etc., the author means the hypochlorite.—Tr.

testing the strength of the chemicks are indicated in Chapter XIV.

Some bleachers still rest satisfied with taking the gravity of the chemicks with a hydrometer. Hydrometers only indicate the density of the solutions, and not the chlorometric strength. As the chlorometric strength and density do not always correspond, this mode of testing should be abolished, as it only yields but very coarse approximations and occasions mistakes of great damage to the fabrics.

#### CHEMICK TANKS.

The chemick tanks may be constructed of wood if to be used with weak chemicks. Generally they are constructed of masonry lined with cement.

*Wooden Cisterns or Troughs.*—The vats have a round or square form. They are provided with a false wooden bottom. This false bottom is formed of wooden laths at a certain distance from each other, and fixed to cross pieces or by boards joined together and pierced with holes. The vat is emptied by a hole made in the side in the space between the bottom and the false bottom. It is closed in the easiest way by a wooden spigot. Cisterns are rarely made with a diameter greater than 2 or  $2\frac{1}{2}$  metres (say  $6\frac{1}{2}$  to 8 feet). If required of greater capacity, they are made of a rectangular shape.

*Cisterns constructed of Masonry.*—Masonry cisterns are rectangular in form; it is advantageous to have several of them arranged consecutively. The bottom of the beck communicates with a cast-iron pipe with a centrifugal pump, which re-delivers the liquid into any one of the cisterns. Working in this way, when a chemick has acted for the necessary time, the liquid is drawn off by the pump and transferred to another tank, where it is kept in reserve. The chemick is replaced by water, and the fabrics may thus remain without danger until it is convenient to wash them. By running the water on



to the top of them for a considerable time, a first washing is given to the fabrics in the chemick cistern ; but this is not sufficient, it has to be followed by washing in the machines.

The fabrics are placed in the chemick cisterns by the aid of delivery rollers and reels. A special reel is used to draw the fabrics from the one side of the cistern to the other during the progress of the chemick ; the operation is termed reeling. By this excellent process the chemick is made to thoroughly penetrate every portion of the fabrics and at the same time to expose them whilst impregnated with chlorine to the action of the air, which still further stimulates the bleaching. A speed of 3,000 to 4,000 *metres* an hour answers very well. A man stows them with a stick on the side on which they fall back.

For washing purposes the reels are arranged in such a manner that the pieces are drawn from the chemick cistern by the washing machine. If the fabrics are to be collected in packets or bundles to be afterwards washed with the dash wheel or the stocks, the rollers may deliver them at a speed of 5,000 *metres* (say 3 miles) per hour for light fabrics, and 3,000 *metres* (say  $1\frac{3}{4}$  mile) for heavy goods.

Cotton goods, more easily bleached than linen, rarely require reeling. In this case it is advisable to use the pump to circulate the chemick by drawing it from the bottom of the cistern and re-delivering it on to the surface. The chemick, being constantly on the move and forced to pass through the fabrics, penetrates them better.

#### CHEMICKING.—DIFFERENT METHODS.

*Stowing with the Feet.*—Round wooden vats, the diameter of which does not exceed 1 to 1.2 *metre* are to be preferred. The chemick is prepared of the desired strength and temperature, and is well stirred so as to mix it thoroughly ; then the

fabrics in parcels are thrown in after slackening the cord which binds them. A man shod with indiarubber boots mounts on the top of them and stamps them down until they are well ingulfed and have no further tendency to reascend. If the strength of the chemick be weak ( $0.30^{\circ}$  chlorometric strength at the maximum) and the temperature about  $25^{\circ}$  C., the man who stows them does so barefooted and barelegged; this enables him to work with greater freedom. The chemicking process being at an end, the chemick is run away or collected in another cistern, water is run on the fabrics, and they are withdrawn to be conveyed to the washing machines. This method of stowing is only suitable for light fabrics, and there are but few causes of damage to be feared.

*Stowing with a Stick.*—The chemick being prepared in the cistern and stirred, a reel delivers the fabrics and a man immerses them in the bath with a stick as they arrive. This method of stowing is very good, because the chemick penetrates well throughout the entire fabric.

*Stowing in the Dry.*—When fabrics of a spongy texture are to be chemicked, such as dry piqués or swanskin piqués (piqués secs ou molletonnés), they are stowed in the chemick cistern as they come from the lye-boil keir, after having been washed in the latter by a current of water which still leaves them lukewarm. They are kept down by wooden cross pieces, a pump causes the chemick prepared in another tank to flow on to the top, and withdrawing it from the bottom circulates it through the fabrics. This circulation ought to go on for at least two hours.

The advantage of this method of working is the ability to place a great weight of fabrics in a comparatively small space, but it is necessary to stow the goods very regularly, and that the fabrics themselves are of so spongy a nature as to be easily penetrated by the chemick.

This method of working is not to be recommended for

linen fabrics. The attempts made by the author yielded bad results. He has employed it with success in the case of cotton fabrics such as piqués, ribbons. The fabrics were simply washed in the lye-boiling keir, and not by the machine; they were still hot and in a condition which favoured the penetration of the chemick. Any lye which they might still retain has only the effect of slightly retarding the action of the chemick. The chemicks given did not exceed  $0.35^{\circ}$  chlorometric strength. In the beginning the temperature of the chemick in contact with the fabrics rose to  $35^{\circ}$  C., then, as the effect of circulation, cooled to  $25^{\circ}$  C.

*Chemicking in the Washing Machine.*—Certain cotton fabrics, such as spongy goods, light calicoes, etc., are chemicked by passing the pieces into a washing machine containing chemick. The chemick is renewed as fast as it is absorbed. As the fabrics issue from the washing machine they are piled on a wooden board, where they remain about three hours; during this time the chemick continues to act upon them. Care must be taken that no portion dries whilst impregnated with chemick.

The fabrics are then washed in the washing machine, and soured in the usual way.

*Reeling.*—As already indicated, this operation consists in passing the fabrics by the aid of rollers from the one side of the chemicking trough to the other. The object is to thoroughly impregnate the fabrics with chemick, and, by moving them through the liquor, to cause the chemick to penetrate as far as possible into the interior of the fibres. This operation is almost indispensable for tightly woven linen fabrics, especially if tightly packed in chemicking troughs. Cotton fabrics are not in general reeled; they are more easily bleached than linen fabrics. A man is required to immerse the fabrics with a stick as the reel brings them from the other side of the trough.

The expense in labour is largely compensated by the better white.

The operation of reeling is more especially useful in the first and second chemick.

#### STRENGTH, TEMPERATURE AND DURATION OF CHEMICKS.

In the examples of bleaching processes (Chapter XII.) the degrees, temperatures and duration of chemicks which are indicated have been most successfully employed by the author. Some general ideas will therefore only be given here.

When chloride of lime is used it is not advisable to heat it. This bleaching agent is used in the bleaching of linen and hempen yarn and coarse sheeting of the same materials.

Yarns from No. 0 to No. 16 are treated with chemick of  $2\cdot5^{\circ}$  chlorometric strength; from No. 16 to No. 30,  $1\cdot5^{\circ}$  to  $2^{\circ}$ ; from No. 30 to No. 50,  $1\cdot0^{\circ}$  to  $1\cdot5^{\circ}$ . Above No. 50 the strength should not exceed  $1^{\circ}$ . The steep lasts from 1 to  $1\frac{1}{2}$  hour.

Many bleachers employ chloride of lime for coarse sheeting, because it costs less than chloride of soda.

The strength of the chemick and duration of the steep:—

Order of Chemick.	Strength in Chlorometric Degrees.	Duration.
1st Chemick - -	$0\cdot8$ to $1\cdot0$	3 hours
2nd Chemick - -	$0\cdot6$ to $0\cdot8$	3 hours
3rd Chemick - -	$0\cdot3$ to $0\cdot4$	3 hours

In summer, the temperature of the chemicking liquor being higher, the strength must be diminished from one to two-tenths of the degree indicated in the table. In winter it must be increased in a similar ratio. The table is constructed for an average temperature of  $15^{\circ}$  C. ( $60^{\circ}$  F.).

For fine linen and cotton fabrics it is advisable to use chloride of soda: greater security and soundness in the fabrics more than compensates for the increased expenditure.

*The Temperature of the Chemicks.*—The temperature of the chloride of soda chemicks may be increased without danger to 25° C. They then acquire a much more energetic bleaching action.

The following examples show the difference in the action between hot and cold chemicks :—

### 1. CHEMICKING FOR PIQUÉS SECS AND SWANSKIN PIQUÉS, COTTON RIBBONS, ETC.

*Hot Chemick.*—Chloride of soda heated to 25° C. used on fabrics coming from lye-boil, washed in the keir, and not by the machine :—

Order of Chemick.	Strength in Chlorometric Degrees.	Duration.
1st Chemick - -	0'35	6 hours
2nd Chemick - -	0'25	6 hours
3rd Chemick - -	0'15	4 hours

*Cold Chemick.*—Chloride of soda at a temperature of 12° to 15° C., acting on the same kind of fabrics, having been washed in the washing machine after being lye-boiled :—

Order of Chemick.	Strength in Chlorometric Degrees.	Duration.
1st Chemick - -	0'95	3 hours
2nd Chemick - -	0'90	3 hours
3rd Chemick - -	0'60	3 hours

### 2. CHEMICKING OF FINE LINEN AND MUSLINS.

*Hot Chemick.*—Chloride of soda heated to 25° C. :—

Order of Chemick.	Strength in Chlorometric Degrees.	Duration.
1st Chemick - -	0'35	5 hours
2nd Chemick - -	0'30	5 hours
3rd Chemick - -	0'20	4 hours



*Cold Chemick.*—Chloride of soda at 12° to 15° C. :—

Order of Chemick.	Strength in Chlorometric Degrees.	Duration.
1st Chemick - -	0.65	3 hours
2nd Chemick - -	0.65	3 hours
3rd Chemick - -	0.50	3 hours

The same degree of whiteness is obtained with these chemicks provided the fabrics are lye-boiled in the same way. It therefore devolves on the bleacher to see whether it will be more advantageous to be economical in coal or make a saving in chloride of soda. If he cannot, for want of the necessary plant, preserve his chemicking liquors, and is obliged to run them away after each operation, it is evident that it will be more profitable to employ weak, warm chemicks.

*Preparation of the Fabrics to be Chemicked.*—It is very important that the fabrics to be chemicked are not impregnated with water, because the water hinders the chemick from penetrating them, and retards its action much longer. The goods, therefore, should be allowed to drain well when they come in drenched from the bleaching green. It is a good plan to wring them, but that is not always possible. In such a case the chemick is made a little stronger. They should not be dry, as in that case the chemick may act on them too energetically. In such a case they should be moistened.

When the fabrics come out of the lye-boiling keir it is not necessary to wash them in the machine. It is sufficient to run water on them in the keir to remove the lye, and let them drain. If a little lye remain, it will render the chemick a little alkaline and retard its bleaching power, but that does not injure the fabrics.

The fabrics as they come from the keirs are still warm, their pores are open, and they are in very good condition for being acted on by the chemick. This observation is appli-

cable—more especially applicable—to cotton goods, as linen fabrics are chemicked as they come back from the bleaching green.

*Quantity of Chlorine used on the Fabrics and absorbed by them.*—This quantity depends upon the manner in which the fabrics have been lye-boiled before the chemick. They will absorb so much the less the longer they have been lye-boiled, and the nearer they are to being bleached white.

*First Example.*—Eight hundred and fifty *kilogrammes* of cotton ribbons were lye-boiled in Mather's keir and first-chemicked in 5,500 *litres* of liquor of  $0.35^\circ$  chlorometric strength, and at the end of six hours this liquor titrated  $0.28^\circ$  chlorometric strength. The liquor thus lost strength to the extent of  $0.7$  chlorometric degrees. Therefore the quantity of chlorine absorbed by the fabrics was  $5,500 \times 0.7^\circ = 385$  *litres* of gaseous chlorine, according to the definition of the chlorometric degree or the equivalent of  $\frac{385}{30} = 13$  *kilogrammes* of Brochoki's chlorozone ( $30^\circ$  chlorometric to the *kilogramme*). As this liquid still titrated  $0.28^\circ$  chlorometric, it was advantageous not to run it away after use; it was preserved for a future operation.

The total quantity of gaseous chlorine contained in the cistern was  $5,500$  *litres*  $\times 0.35^\circ = 1,925$  *litres*, say 64 *kilogrammes* of chlorozone, and the quantity of gaseous chlorine per *kilogramme* of fabric was  $\frac{1925}{850} = 2.2$  *litres*.

The quantity of gaseous chlorine absorbed by the *kilogramme* of fabric,  $\frac{385}{850} = 0.45$  *litre*.

The quantity of chlorinated liquid per *kilogramme* of fabric was  $\frac{5500}{850} = 6.5$  *litres*.

The ribbons were piled in the cistern, curbed down, and a centrifugal pump circulated the chemick during the steep.

*Second Example.*—Three hundred and five pieces of cambric muslin weighing 1,350 *kilogrammes* were chemicked for the first time in a liquor testing  $0.24$  chlorometric degrees. They were reeled twice in the chemick, and withdrawn after five

hours' steep. At the end of this the chemick titrated  $0.17^\circ$  chlorometric strength.

The quantity of liquid employed was 31,200 *litres*, representing  $31,200 \times 0.24^\circ = 7,488$  *litres* of gaseous chlorine, or 250 *kilogrammes* of Brochoki's chlorozone. The cambrics were spread over four cisterns, each containing 7,800 *litres* of liquid of  $0.24^\circ$  chlorometric strength. There were therefore 76 pieces in each cistern, but they generally contain 100.

Taking into account the quantity of liquid retained by the pieces, there were recovered per cistern 6,000 *litres* of liquid of  $0.17^\circ$  chlorometric strength, say a total of  $6,000 \times 4 \times 0.17^\circ = 4,080$  *litres* of gaseous chlorine, or the equivalent of  $\frac{4080}{30} = 136$  *kilogrammes* of Brochoki's chlorozone.

The quantity of liquid employed per *kilogramme* of fabric was  $\frac{31200}{1350} = 23$  *litres*, but generally it does not exceed 16 to 17 *litres*.

The quantity of gaseous chlorine per *kilogramme* of fabric was  $\frac{31200 \times 0.24}{1350} = 1.6$  *litre*.

*Third Example.*—Four hundred and eighty pieces of cambric muslin weighing 2,000 *kilogrammes* were chemicked the second time in a liquor titrating  $0.21^\circ$  chlorometric strength.

The pieces were reeled twice and steeped seven hours in the chemick. The titrations gave the following results:—

	DEGREES CHLOROMETRIC STRENGTH.						
Original chemick	-	-	-	-	-	-	$0.21$
After 2 hours	-	-	-	-	-	-	$0.20$
" 4 "	-	-	-	-	-	-	$0.19$
" 7 "	-	-	-	-	-	-	$0.19$

It will be seen, therefore, that the chemick has no action after the first four hours. The fabrics should therefore be withdrawn at the end of that time.

The quantity of liquid used was 39,000 *litres*, representing  $39,000 \times 0.21^\circ = 8,190$  *litres* of gaseous chlorine, or  $\frac{8190}{30} = 273$  *kilogrammes* of chlorozone ( $30^\circ$  to the *kilogramme*).

The chemick having fallen from  $0.02^\circ$  chlorometric strength, the total quantity of gaseous chlorine absorbed was  $39,000 \times 0.02^\circ = 780$  litres, or  $\frac{780}{3.0} = 26$  kilogrammes of Brochoki's chlorozone.

Each kilogramme of fabric has absorbed  $\frac{780}{2000} = 0.39$  litre of gaseous chlorine. The quantity of liquor recovered was  $30,000 \times 0.19^\circ = 5,700$  litres of gaseous chlorine, or  $\frac{5700}{3.0} = 190$  kilogrammes of chlorozone. The remainder of the liquid was retained by the fabric.

*Table of the quantity of Chlorinated Liquid (Chemick) to be used in proportion to the weight of Fabric.*—This quantity depends upon the manner in which the fabrics are chemicked. The object of the table is to afford data for the construction of new cisterns, and a point of comparison with those already existing.

Dimensions of the Cisterns.	Quantity of liquid in litres.	Weight of the fabrics.	Quantity of liquid per kilogramme of fabric.	Observations.
$3^m \times 2 \times 1.80$ Vol. 11,000 litres	7,000 to 8,000	1,500 kilos. to 2,000 kilos.	4 to 4.6 litres	The volume occupied by the fabrics is 6,000 to 7,000 litres. The fabrics are piled in the dry, curbed, and the liquid is run in below by a pump. This method of piling the goods is only suitable for spongy fabrics.
Round Cistern— Diam. 1.35 H. 1.10 Vol. 1,560 litres	1,100	150 kilos.	7.3 litres	The chemick is prepared in the cistern and the fabrics are packed into it with the feet or by a stick.
$3^m \times 2 \times 1.50$ Vol. 9,000 litres	7,800	450 kilos.	17 litres	This tank is divided into two compartments for reeling the fabrics, which occupy in turn first one compartment and then the other.

*Preparation of Chemicks.*—The chlorides sold in commerce or prepared in the works have a greater or less degree of strength, and must be diluted before use. To know the quantity of water which should be added to the liquid chloride it is necessary to ascertain the chlorometric strength of the liquid; it is titrated by one of the known methods.

If  $N$  be the chlorometric strength in degrees of the concentrated chloride, and  $N^1$  that of the chemick which it is desired to make, it is required to determine the proportion of water and concentrated chloride to use to make  $L$  *litres* of chemick of  $N^1$  degrees chlorometric strength.

The number of *litres* of gaseous chlorine remaining constant, and calling the number of *litres* of concentrated chloride to be used  $X$ , we have—

$$L \times N^1 = X \times N, \text{ whence } X = \frac{L \times N^1}{N}.$$

Supposing that it be desired to make 3,000 *litres* of chemick of  $0.70^\circ$  chlorometric strength, using Brochoki's chlorozone testing  $35^\circ$ , the number of *litres* to dilute with water to the volume of 3,000 *litres* will be—

$$X = \frac{3000 \times 0.70}{35} = 60 \text{ litres.}$$

It is therefore necessary to take 60 *litres* of chlorozone and complete the volume of 3,000 *litres* with 2,940 *litres* of water; in actual practice and to simplify matters, 3,000 *litres* of water and 60 *litres* of chlorozone. This will not make any sensible change in the strength, provided there be a considerable difference between the strength of the concentrated chloride and that of the chemick to be prepared.

A similar calculation is made when it is desired to increase the strength of a chemick. Suppose that it be desired to raise 1,000 *litres* of chemick of  $0.5^\circ$  chlorometric strength to



0.7°. The difference being 0.2°, the quantity X of chlorozone to employ would be—

$$X = \frac{1000 \times 0.2}{35} = 5.7 \text{ litres.}$$

So as not to be under the necessity of making these calculations each time, a table is prepared giving in one column the strength of the usual chemicks, and opposite, in the other column, the quantity of concentrated chloride of a certain strength to use in order to have 1,000 *litres* of chemick.

The liquid chloride of lime obtained by working up the solid chloride of lime with water is generally 8° in chlorometric strength. This strength of 8 chlorometric degrees supposes that 80 *kilogrammes* of chloride of lime of 100° strength have been worked up with 1,000 *litres* of water (say 80 lb. per 100 gallons).

#### LIQUID CHLORIDE OF LIME OF 8° CHLOROMETRIC STRENGTH.

I.	II.	Remarks.
0.10°	12.5	The first column gives the chlorometric strength of the desired chemicks.
0.20°	25	
0.30°	37.5	
0.40°	50	
0.50°	62.5	
0.60°	75	
0.70°	87.5	
0.80°	100	The second column indicates the number of <i>litres</i> or gallons of chloride of 8° chlorometric strength which is required to be diluted with water to a volume of 1,000 <i>litres</i> or gallons respectively so as to have a chemick of the strength indicated opposite.
0.90°	112.5	
1.00°	125	
1.25°	157.25	
1.50°	187.50	
1.75°	218.75	
2.00°	250	
2.25°	281.25	
2.50°	312.50	
2.75°	343.75	
3.00°	375	

CHLORIDE OF SODA OF 35° CHLOROMETRIC STRENGTH OR  
BROCHOKI'S CHLOROZONE.

I.	II.	Remarks.
0°05'	1'43	The first column gives the chlorometric degrees of the desired chemick.
0°10'	2'86	
0°15'	4'30	The second column indicates the number of <i>litres</i> or gallons of chlorozone of 35 chlorometric degrees which it is required to dilute with water to 1,000 <i>litres</i> or gallons respectively in order to get a chemick of the chlorometric strength indicated opposite.
0°20'	5'75	
0°25'	7'15	
0°30'	8'58	
0°35'	10'00	
0°40'	11'43	
0°45'	12'85	
0°50'	14'30	
0°55'	15'75	
0°60'	17'15	
0°65'	18'58	
0°70'	20'00	
0°75'	21'43	
0°80'	22'85	
0°85'	24'30	
0°90'	25'75	
0°95'	27'15	
1°00'	28'60	

## CHAPTER IX.

### SOURS.

PROPERTIES OF THE ACIDS.—*Hydrochloric Acid—Sulphuric Acid—Acetic Acid—Oxalic Acid.*

EFFECTS PRODUCED BY ACIDS.—*Lime Sour or Grey Sour—Duration of Steep—Temperature of the Sour—Strength of Sour—Method for Strengthening previously used Acid.*

SOURING CISTERNS.

### PROPERTIES OF THE ACIDS.

THE acids most generally used in bleaching are hydrochloric acid and sulphuric acid, and, more rarely, oxalic acid and acetic acid.

*Hydrochloric Acid.*—Hydrochloric acid, or muriatic acid, is a gas, and liquid hydrochloric acid is a solution of this gas in water. The density of the hydrochloric acid of commerce is  $1.13^{\circ}$ , and it registers  $22^{\circ}$  with Baumé's hydrometer. When pure it is colourless, but the commercial acid is coloured yellow by a trace of iron. Its price varies between four and five francs the 100 kilogrammes, say 2s. to 2s. 6d. per cwt.

*Sulphuric Acid.*—Sulphuric acid is an oily liquid, colourless if pure, blackish yellow if it has been in contact with organic matter, which it burns. It has generally a density of  $1.84$ , and registers  $66^{\circ}$  Baumé. The temperature of the liquid should be  $15^{\circ}$  C.

Hydrochloric Acid 22° B.		Sulphuric Acid 66° B.	
Degrees Baumé.	Number of litres per cubic metre, or gallons per 100 gallons.	Degrees Baumé.	Number of litres per cubic metre, or gallons per 100 gallons.
0·1	4·5	0·1	1
0·2	9	0·2	2
0·25	11	0·25	2·1
0·5	22·5	0·5	4
0·75	34	0·75	7
1	45	1	8
1·5	70	1·5	12
2	90	2	17

Baumé's hydrometer is used to test the strength of the sours, but care must be taken to work at 15° C.

*Acetic Acid.*—Acetic acid is one of the products of the destructive distillation of wood. It may contain tar and sulphuric acid, originating in the decomposition of the acetate of lime by sulphuric acid.

Acetic acid does not attack vegetable fibres, and the salts which it forms with carbonates and hydrated oxides are very soluble. These two properties adapt it well for use in bleaching, and it is to be regretted that its high price forms an obstacle to its use.

*Oxalic Acid.*—This is used in the form of oxalic acid, oxalate of potash, acid oxalate of potash. Oxalic acid dissolves salts of iron; it is used to remove rust stains and the yellow tint which ferruginous water imparts to the fabrics.

#### EFFECTS PRODUCED BY ACIDS.

Acids diluted with water to a suitable strength do not exert an injurious action on vegetable fibres; they slightly attack the colouring matter of linen and cotton, rendering it brighter, but their rôle in bleaching is to free the fabrics from deposits and dirt, as well as from the salts which they retain after the lye-boils and the chemicks.

The alkaline lyes dissolve resinous principles, forming more or less soluble soaps. The washings which follow the lye-boils remove these substances, but not always completely. For example, after the washing following the lime-boil the fabrics must be soured with hydrochloric acid to remove all trace of lime. A sour following a first lye-boil with soda produces very good results and prepares the fabrics well for the next boil.

The fabrics as they come from the chemick retain a yellow tint even after washing. A sour removes this tint and drives off all trace of chlorine.

Hydrochloric acid makes a suitable sour after lime (*Grey sour*) or soda, especially after lime, as sulphuric acid would form, with lime, sulphate of lime, an almost insoluble salt. After the chemick, sulphuric acid is used in the *White sour*, because its action on the fabric is preferable.

The last bleaching operation should be a sour, because it leaves the fabric with the brightest colour and the one most pleasant to the eye. But this sour must be followed by especially good washing. Otherwise, when the fabrics are blued, the blue, especially ultramarine blue, is quickly destroyed by the traces of acid remaining. When any acid remains in the fabrics, it is very injurious to them, especially when they are dried in that condition; if they are then ironed with a hot iron, they lose their soundness and are more or less burnt. This is the reason why bleachers who do not possess washing machines perfect enough for this purpose only give a wash after the first chemick. Others prefer for a final operation a weak boiling with carbonate of soda lye slightly tinted with blue, or a soaping, the whole followed by a wash. If the whole of the soap be not well removed the fabrics will have a great tendency to turn yellow in the warehouse.

Some bleachers steep the fabrics from twenty to thirty minutes in a weak hydrochloric acid sour, heated to about



90° C. (194° F.). This operation brightens up the heart of the fabrics and removes grease, but it is especially useful in removing the yellow tint due to ferruginous waters. If the waters be not ferruginous, a sulphuric acid sour, well given as a finish, will produce the same effect and cost much less.

When parts of the fabrics are of different colours it is not prudent to sour them, as some colours would not resist and would be more or less attacked. In such a case they are not soured, or, if so, the pieces are run rapidly through a souring cistern containing very dilute sulphuric acid (1 *litre* per cubic *metre*, or 1 gallon per 1,000 gallons), and then washed immediately. If the sulphuric acid be still too energetic, oxalic acid is used, the action of which is not so rapid. Oxalic acid may be replaced by acetic acid. Oxalic acid brightens blue colours, and acetic acid brightens black colours. In order to ascertain the strength of the sours made with these two acids, the workmen dip their finger in the acid and put it in their mouth. The acid should slightly "bite" the tongue.

A double roller washing machine answers very well for souring; the acid is in the first cistern, and water constantly being renewed for washing in the second.

*Rough Sour.*—The treatise on bleaching published in Ireland under the title of *Hints to Bleachers* gives the following process for what it calls a rough sour: "This sour is given to fabrics as they come from the bleaching green before they have been in any way chemicked. It is thought that it opens the fibres of the yarn and enables the chemick to act more effectually in the subsequent operation. It is also thought to cause the greenish tint which begins to show itself at this stage to disappear. Some old bleachers do not give a 'rough sour'. They say that it hardens the yarn, and that the chemick cannot, therefore, penetrate into the heart of the fabrics. But that is no explanation, since the sour brightens the fabrics and removes the deposits which remain therein

after boiling. When the fabrics come out of this sour they are more supple to the touch than when they come out after being boiled, and the heart is brighter. Sometimes it economises one of the bleaching operations, because, when the fabrics are taken at the right time, and soured in this way, the resultant effect contributes greatly in quickly producing a perfect white."

The author has not used this sour immediately before the first chemick, but he has given, with much success, a hydro-chloric acid sour between the first and the second boiling.

*General Recommendation.*—Whatever may be the arrangements made for souring, they ought to be such that the fabrics are well impregnated all throughout their parts. None of them should be exposed to the air and dry there, either by swimming above the cistern or in the interval between the sour and the washing. That is why the fabrics are washed as soon as they come from the sour.

*Duration of Steeps.*—When strong sours are used, *i.e.*, when the gravity varies between 1° and 2° Baumé, a three hours' steep is sufficient. When weak, *i.e.*, when their gravity is less than 0.25° Baumé, a ten to twelve hours' steep is necessary.

If the fabrics be not steeped long enough, there will not be time for the effect to be produced ; but there is no disadvantage in leaving them longer in the sour ; they may remain a day or two without being damaged.

If it be not desired that the fabrics be steeped for such a long time, and it be not possible to wash them forthwith, the acid is run off, or run into another cistern, and replaced by water. By renewing the water every twenty-four hours the fabrics may be left for three or four days in the souring cisterns without risk.

*Temperature of the Sour.*—Sours heated to 25° to 30° C. have much greater action than cold sours. Weak hot sours may, therefore, replace cold strong sours, and the same result be obtained.

*Souring Strength of the Sours.*

*First Method.*—Mix the acid in the cistern, and heat to 27° C. (81° F.). Throw in the untied bundles, and immerse them with a stick ; or, better still, a man packs them with his feet by tramping upon them.

Sours are made in the following proportions:—

Hydrochloric acid sour after lime : 5 *litres* of acid per cubic *metre* of water (or 5 gallons per 1,000 gallons).

Sulphuric acid sour after chemick : 2 to 3 *litres* of acid per cubic *metre* of water (2 to 3 gallons per 1,000 gallons).

These sours are suitable for squeezed fabrics, because, if impregnated with water, acid would not penetrate them, and its action would be insufficient.

After ten hours these acids are exhausted, and are not worth recuperating.

*Second Method.*—If the fabrics be not squeezed, the following sours are used, after heating to 27° C. (81° F.). The steep lasts six to twelve hours.

Hydrochloric acid sour after lime : 0·5° to 0·75° Baumé, or 22 to 34 *litres* per cubic *metre* of water (22 to 34 gallons per 1,000 gallons).

Sulphuric acid sour after chemick : 0·5° Baumé, or 4 *litres* per cubic *metre* of water (4 gallons per 1,000 gallons).

In regard to calicoes, a mixture of hydrochloric and sulphuric is used after the chemick in the ratio of 4 *litres* of sulphuric acid and 4 *litres* of hydrochloric acid per cubic *metre* of water (4 gallons of each per 1,000 gallons).

*Third Method.*—If the sours be not heated, and if the fabrics be not squeezed, the following strengths are used with a three hours' steep:—

Hydrochloric acid sour after lime : 2° Baumé, or 90 *litres* of hydrochloric acid per cubic *metre* of water (90 gallons per 1,000 gallons).

Sulphuric acid sour after chemick: 1° Baumé, or 8 *litres* of sulphuric acid per cubic *metre* of water (8 gallons per 1,000 gallons).

If a mixture of sulphuric and hydrochloric acid be used for souring calicoes, 8 *litres* of sulphuric and 4 *litres* of hydrochloric acid are used per cubic *metre* of water (or 8 gallons and 4 gallons per 1,000 gallons).

*Remark.*—The sours of these two last categories should not be run away; they should be preserved for another operation, after having added the acid which has been absorbed by the fabrics. They are only thrown away when too dirty.

Whatever strength of sour be used, the bleacher ought to satisfy himself that the acid has penetrated well into all the parts of the fabrics. As they come out of the sour they should all present a uniform tint; there should be no yellow or grey portions alongside bright parts.

If the fabrics be bulky and compact, it is well to pass them through a saturating beck filled with sour.

*Method of Reinforcing the Strength of previously used Sour.*

The strength of fresh acids is tested by Baumé's hydrometer, taking care to cool the acid to about 15° C. (say 60° F.). If the acid which has been used be tested, it will be seen that its gravity has not changed appreciably, because the substances dissolved preserve its original density.

To ascertain the quantity of acid absorbed, it is tested to see how much soda is required to saturate 10 cubic *centimetres* of the original sour, and how much to saturate 10 cubic *centimetres* of the same sour after use. The difference between these two quantities gives the proportion of acid absorbed.

For weak sours 10 *grammes* of caustic soda are dissolved in a *litre* of water. Take 10 cubic *centimetres* of the fresh sour



and colour it red with litmus. Fill a graduated burette with the soda solution, and run it in, drop by drop, until the red turns blue, and note how many divisions you have run in. Recommence the same operations with 10 cubic *centimetres* of the sour which has been used, and note the number of divisions run in.

Suppose that in the case of the original sour you have run in 30 divisions, and 20 in the case of the sour that has been used, these figures would indicate that one-third of the acid had been absorbed. To bring the sour to the strength necessary for a further operation, it will be necessary to add one-third of the acid used for the original sour. This test is not made for each sour; it is verified two or three times, and the same quantity always added to revivify the sour. The bleacher confirms, by Baumé's hydrometer, if the gravity is about what is wanted.

The sours for fabrics coming from the chemick may last several months; they are run off when too dirty. The sours for fabrics coming from lime bucking become dirty much sooner.

#### SOURING CISTERNS.

In the construction of these materials are used which are not attacked by acids. Cisterns of granite, with cement joints, resist weak acids very well. Generally lead-lined pine wood becks are used. Lead costs dear, and, besides, has the inconvenience of tearing very easily. The best thing is to use well-jointed wooden becks without any inside lining whatever.

The sides of the beck should not be crossed by iron rods, for in a very short time the wood is impregnated with acid, which rusts the iron. The boards will be well joined match-board-wise or otherwise outside; wooden cross pieces joined together by bolts will keep the boards pressed one against the other.



Wooden becks ought to be placed so that they can be easily got at for repair and inspection.

When several cisterns are laid down, one after another, they are made to communicate together by lead pipes. Cast-iron or bronze taps are quickly attacked by acids; it is preferable to use ebonite or stoneware taps, in spite of their fragile nature. The author has also used wooden taps, which resist feeble acids very well, and have, moreover, the advantage of not costing much.

The sours are transferred from one cistern to another by a pump or injector. The centrifugal pumps should be of bronze, and not of cast iron, and in spite of that they wear very rapidly. If the sours be strong, ebonite or earthenware pumps should be used.

Injectors are very convenient for transferring sours; the steam dilutes them a little, and raises their temperature, which is no very serious inconvenience, since we have said that these sours are used at a temperature of  $25^{\circ}$  C. ( $77^{\circ}$  F.). We have successfully used Koerting's injectors, made of special metal, which acids attack but little. This firm also makes them in porcelain. These appliances, in order to work well, must be placed opposite the bottom of the cisterns. They should only work by pressure.

In the same way as in chemicking, it is very advantageous to saturate the fabrics with acid before piling them in the cistern. This saturation may be done in a roller-washing machine or by simply running them through a small cistern.

## CHAPTER X.

### DRYING.

#### *Drying by Steam—Drying by Hot Air—Drying by Air.*

AFTER the fabrics are bleached white they receive a final washing. This washing should be done with special care, and in a water specially adapted for the purpose, so as to free the fabrics from all trace of the chemicals used in bleaching. This operation is one of the most important, for any traces of soda, chlorine, or acids remaining in the tissues would, in the drying, act very injuriously.

It is rare that fabrics are dried before being blued and finished. It forms no part of the plan of this work to treat upon finishing, but a few words may be said in regard to drying, because it has an influence on the quality of the white and its preservation.

Drying may be effected by steam, hot air, or air at the ordinary temperature of the atmosphere.

*Drying by Steam.*—The fabrics are dried over a series of copper rollers, the interior of which is heated by steam. This mode of drying, which is the most rapid, answers very well for cotton fabrics. It does not suit so well for linen or hemp. It renders them harsh to the touch, and does not allow the grain to appear; they assume a glazed, cotton-like appearance, which must be avoided. If this method be used to save time with linen or hemp fabrics, they must not be completely dried by the machine, but finished in a free air drying machine. When the fabrics are not very white the drying on the

cylinders turns them yellowish, and if they have been blued, the union of the yellow and the blue gives them a greenish cast.

The fabrics are kept extended during drying on tenter frames, the fabrics being seized hold of by the selvage and kept in position by pegs and cords. The pieces pass above the pipes, but do not come in contact with them.

*Drying by Hot Air.*—In this method of drying the yarn or fabrics are exposed in apartments heated by steam pipes. The yarns are stretched on poles; the fabrics are spread out in the same manner, or, better still, placed horizontally one above the other, supported at regular intervals by horizontal cross pieces. The ends of the pieces are rolled over a wooden bar, to the ends of which two cords are attached, which roll upon a windlass, and by this means the piece is kept stretched throughout its length.

Instead of heating the drying apartment by steam pipes, a machine is used which heats the air in contact with the steam pipes, and propels this hot air into the drying room.

Whether drying be done by machine or in a heated apartment, care must be taken to remove the air. This is indispensable, for the air soon becomes saturated with steam, and the fabrics to be dried cease to part with their moisture. So that evaporation may go on continuously, the humid air must be expelled and replaced by a fresh quantity of dry air.

If powerful ventilation be desired, mechanical ventilators are used. The author has employed Blackmann's air propeller with success; it can be easily installed, and requires but little motive power to put it in movement.

*Air Drying.*—This is the longest method of drying, but it gives the best results as far as linen and hemp fabrics are concerned. Special drying rooms are constructed for large sheets the length of which varies from 100 to 130 metres (say 110 to 145 yards); they are the length of the pieces, say 130

*metres*. Their width is such that two rows of pieces may be stretched, leaving a wide passage in the middle and two narrow gangways on the sides. This involves a total width of 5 *metres* (say 16 feet). The height is  $2\frac{1}{2}$  *metres* (say 8 feet). The sides of the drying room are closed by Venetian blinds, the laths of which are movable round an axis; this enables the room to be aerated in accordance with the state of the atmosphere. Posts placed at a distance of 3 to 4 *metres* (say 10 to 13 feet) carry horizontal cross pieces on which the pieces are stretched one above the other without touching.

## CHAPTER XI.

### DAMAGES TO FABRICS IN BLEACHING.

*Yarn—Mildew—Fermentation—Iron-rust Spots—Spots from Contact with Wood—Spots incurred on the Bleaching Green—Mice and Insect Holes—Tar and Grease Spots—Small Holes—Fabrics turning Yellow or Green after Bleaching—Damages arising from the Machines.*

BLEACHING is an industry involving fastidious care. The injuries which the fabrics may receive in the process may involve the bleacher in serious damages. These injuries are often only observed at the finish of the bleaching operations, and it then becomes very difficult to ascertain the cause, and to what defective operation to attribute them. Many injuries are avoided by the bleacher inspecting the fabrics in the course of bleaching, and satisfying himself as to their soundness. If any deterioration is observed the cause should be at once ascertained, and the injury prevented from spreading further.

Some information in regard to the most frequent causes of injury in bleaching is given below, and numerous extracts are made from the *Irish Guide*, which has treated this question very well.

*Yarn.*—Sometimes the warp and the weft are not of the same quality; hence arises a great difficulty in bringing them to the same degree of whiteness without deteriorating them.

When fabrics made from creamed yarn are to be bleached, great annoyance may be caused if the creaming of the thread has been badly done; the fibre has been more or less attacked,



and it is no longer capable of withstanding the operations of bleaching. Bleachers to the trade ought therefore to make stipulations when they bleach fabrics made of creamed yarn, and those firms which bleach their own fabrics should attach much importance to the creaming of their yarn.

The yarn for coarse fabrics must be creamed or at least well boiled, but, as far as the yarn for fine fabrics is concerned, it is much preferable not to cream the yarn before weaving. This permits of energetic washings with lye before the chemick, the operations following are much diminished, and a brighter white is obtained.

*Mildew.*—This is another stumbling-block for bleachers. It shows itself when the fabrics are three-quarters white; it is very difficult to get rid of, for often, the fabrics being sufficiently white, it is necessary to proceed with further operations so as to get completely rid of it. Mildew cannot be seen in the fabrics until they are almost white, unless under the microscope, and when seen through that instrument some portions of the fabric present a brownish black appearance. The black portions are supposed to be mildew, and to get rid of it requires good lye-boiling, a passage through the stocks, and a strong chemick. The stocks expel it from the fabrics. Mildew is often seen on one side of the fabric and not on the other. If it be noticed that the fabrics at the end of the processes show much mildew, they are to be boiled more energetically and more often; after scouring them give them a good chemick. If the mildew appears almost imperceptible ordinary bleaching operations will cause it to disappear; if it be more accentuated it requires much experience and attention to get quit of it, and preserve the strength of the fabric. A strong sour is regarded by some as a good method for getting quit of mildew, but then it must be put to the sour before it goes to the chemick.

*Fermentation.*—This is a frequent cause of injury to the

fabrics. Great care should be taken to avoid fermentation. The following are the principal circumstances under which it is produced :—

During steeping, the gum, grease and resinous matters are dissolved in the tepid water and ferment very quickly. This fermentation is necessary in the beginning to render all these substances soluble, and thus free the fabric from them ; but it must be stopped in time so as not to damage the fabric. This preliminary bleaching operation, which would appear inoffensive since it consists of steeping in tepid water, is, nevertheless, one which requires to be executed with the greatest of care. It is necessary to change the water as soon as it commences to smell badly and is seen to give off bubbles of gas. If the fabric has been damaged, it will not be seen until the bleaching operations are finished, and no one will be able to tell what has been the cause of it.

When wet fabrics are left piled in the bleach works they heat and ferment. A rule should be made never to leave them longer than two days in this condition, and if for any cause operations have to be suspended, it is better to dry them. The leaving of fabrics in piles in summer is especially dangerous. Fermentation is more to be feared in those fabrics which are but little advanced in the sequel of bleaching operations.

The fabrics on the green in contact with the earth are also liable to ferment, even if exposed on mown grass. In winter they sometimes remain under the snow, resting on the bare ground denuded of all herbage. Fermentation is to be feared, induced by the heat of the earth. If it be impossible to lift the fabrics, the snow should be swept off. The fabrics thus exposed to the cold freeze, and fermentation need no longer be feared.

*Iron-rust Spots.*—These are common in bleaching ; they proceed generally from the fact that the fabrics have, when in

the wet condition, come in contact with iron. One moist rust spot makes another. The iron spots on grey fabrics disappear in the course of the bleaching operations. If they are not old they may be removed by hydrochloric acid. But if the fabrics are already white, and it be not desired to employ hydrochloric acid, oxalic acid may be used. Place the stained part above hot water, rub with a little oxalic acid until the spot disappears, and wash well. The spot must be removed on the first attempt, because if the operation has to be repeated, a hole will be driven through the cloth. Spots may be removed with hydrochloric acid in a similar manner.

*Spots from Contact with Wood.*—Blackish spots appear on fabrics which are allowed to remain on wood, which is always moist. This happens especially when they are deposited there full of soap from the stocks. These spots may be removed, like iron rust, by rubbing the stained part with hydrochloric or oxalic acid. A “sour” causes them to disappear partially, but not completely. Care should be taken to prevent the fabrics from coming in contact with oak wood and pine, and generally with every kind of exudation from wood which is not dry, so as to avoid tannin, resin and other spots. Spots produced by wood sap disappear in the chemicks and sours, those of resin in the alkaline lyes. Do not, therefore, use wood which has not been well dried in the construction of tables on which the fabrics are to rest, or to line the interior of vats, etc. A good precaution is to give the wood a coating of milk of lime, and then to scour it well.

*Bleaching Green Stains.*—Generally, these disappear during the first bleaching operations, but if the fabrics are in the advanced stage of bleaching there remains a red spot which a sour alone can remove. There are black stains made by flowers which are difficult to remove and which require the use of a chemick and a sour. There are also grey stains from the heaps of stones on which the fabrics are deposited. Moss

springs up from the cavities and fissures of these stones, which are alternately wet and dry ; consequently, if the fabrics be allowed to remain there whilst the moss is growing, the latter will stain them. The sour will cause these stains to disappear, but the danger is that supplementary processes will have to be resorted to, processes which injure the strength of the fabrics, and render them thinner than necessary.

Earth stains, flower stains, and aquatic moss stains require supplementary treatment for their removal, and care should be taken to prevent their occurrence. There are quite enough difficulties in bleaching without having to resort to fresh processes, which always involve a certain amount of risk. Soot stains and atmospheric dust also cause great annoyance to bleachers. When fabrics well advanced towards the completion of the bleaching processes are stained in this manner, and if the stains cannot be removed by scouring or washing before going to the chemick, they impregnate the tissue, leaving a black spot which cannot be removed without destroying the fabric.

*Insect and Mice Holes.*—Damage by insects is rare. Nevertheless, the author has seen larvæ in the folds of fabrics which have made a hole for their escape. A bleacher told the author that he had to destroy crickets because they made numerous holes in his fabrics. Ordinary mice and field mice gnaw the fabrics on the green, especially in winter. A small premium is generally given to the bleach works hands for killing them, as well as rats.

*Tar and Grease Stains.*—Grease stains produced by the oil or grease used for lubrication are removed by oil. Tar stains are removed by benzine.

*Small Holes.*—There are met with sometimes in fabrics in the advanced stages of the bleaching small holes of two to three millimetres in diameter, frequently repeated, sometimes disseminated over the whole piece, sometimes grouped in certain



parts. In the latter case, the fabric looks as though it had been riddled by shot from a gun. Opinions differ as to the origin of these small holes.

The guide *Hints to Bleachers* says that these holes may be produced during boiling, and that the steam imprisoned in the folds of the cloth escapes by making holes similar to those made by small shot.

Others suppose that they are produced during steeping, either in the chemick or in the sour, without indicating the cause which leads to their production.

The author has had much worry with these small holes, and the explanation which he gives appears rational to him, without affirming that other causes may not give rise to the same annoyance.

It has been noticed that these small holes appear only after the chemick and that they are found in closely woven fabrics, and rarely in loosely spun goods. Now, rain charged with chimney fumes and atmospheric dust falls on the fabrics as they are spread on the green. Now, these fumes contain sulphides, which in contact with the air and with water are transformed into sulphuric acid, and traces of iron, which produce red stains. The fabrics, as they come back from the bleaching green, are generally treated with chemicks without being washed, and the oxidising action of chlorine still further accentuates the effect produced on the fibre by the sulphur or iron derivatives, and makes a hole. These holes are not visible immediately, because the attack is not equal throughout. Small holes begin to be observed after the first chemick, then they are more numerous after the second bath, and so on. It is very probable that the cause which produced them made but a single attack, but as the small spots did not attack the fibres to the same extent, the holes reveal themselves gradually in proportion as the fibre is disintegrated by the chemicals.



The author has been enabled to prevent this damage by carefully washing dust-spotted fabrics on their return from the bleaching green, especially tightly woven goods. When fabrics are nearly white, and when rain is foreseen, which would spot them, it is better to gather them in from the bleaching green or to raise them on to posts, as is done with the large sheetings of Normandy.

It does not do to burn any kind of coal indifferently. Coal containing pyrites and much ash, which would give rise to dust, should be rejected.

*Fabrics turning Yellow or Green after Bleaching.*—It happens that fabrics turn yellow after they have been stored in a shop or warehouse for a shorter or longer period of time. If they appear green instead of yellow, the cause is the same ; it is the union of the yellow with the blue which gives this green cast. The author believes that this phenomenon may be attributed to three different causes.

1. Imperfect bleaching :—

When the fabrics have not been bleached right through there remain colouring principles in the centre of the yarn, which gradually rise up to the surface. In this case the only thing that can be done is to bleach them afresh. The white has not lasted, but the fabric itself is uninjured. A boiling with alkaline lye, a chemick and a sour, or only one of these operations will restore to the fabric its pristine whiteness.

2. Change in the constitution of the textile fabrics :—

The chemicals have altered the constitution of the textile fabrics, either because they have been used in too concentrated a state, or because they have not been effectually washed out. Consequently these substances, intended solely for the removal of the colouring principles, continue to act on the fibre under conditions which are peculiarly injurious ; for example, when the fabrics are dried on the green, or dry without having been washed. The cellulose, which is the essential part of

the fibre, is converted into oxycellulose or hydrocellulose, which assumes a yellow tint after a greater or less lapse of time. The fabric is then more or less tendered.

The origin of this yellow may be ascertained by testing the strength of the fabric. Often this yellow tint is partial, and it is found that the tissue is less sound in those parts which have become yellowish than in the parts which have remained white. The evil that has been done cannot be remedied. Chlorine alone will cause these yellow stains to disappear; alkaline lyes and acids have no effect upon them. Before again drying them they should be washed with the greatest of care, so as to remove every trace of chemical reagents.

3. Obscure or uncertain causes :—

The fabrics, having been bleached and appearing of a beautiful white, are dried, and immediately become yellow or green if they have been blued.<sup>1</sup> This yellow or green tint is much more apparent if the fabrics have been dried at a high temperature. The fabrics would not appear to have been altered in any way, and preserve their soundness. The author has often observed this phenomenon, especially with cottons, and made experiments to find out the cause. The explanations which he endeavours to give are not conclusive, and what follows is simply an hypothesis.

The alkaline lyes dissolve the colouring principles, and these substances are afterwards expelled from the fabrics. It is therefore to be supposed that at a certain moment these products have been baked, that is to say, rendered less soluble. That which was on the surface has been removed, but that which remains in the centre of the yarn has remained there, and, nevertheless, is invisible at the finish of the bleaching processes. If the fabrics be dried at a high temperature, the steam, issuing briskly, brings the coloured products to the surface and causes the yellow or green colouration to appear.

<sup>1</sup> From the union of the yellow with the blue, see p. 137.—TR.

Neither chemick nor sour will remove this colouration, and recourse must be had to a good alkaline lye-boil. Not knowing the cause of this phenomenon, the author cannot say exactly what should be done to avoid it. It happens without any apparent change having been made in the process.

When it manifests itself precautions should be redoubled; care should be taken to avoid passing the fabrics from a high temperature to a low temperature, and *vice versâ*. This would occur for example if the fabrics, whether impregnated with soap or not, were plunged into boiling lye or boiling water, or if the fabrics as taken from a boiling alkaline lye were plunged into cold water. The fabrics should be heated or cooled gradually.

Some bleachers do not think it right to send fabrics to be finished which have been treated with soap as a final operation. Others think that rosin soap should not be used beyond the lyes which precede the chlorine, and that in the succeeding operations olein soap should be used. They think that the former yellows the fabrics.<sup>1</sup>

The laying down or piling of the fabrics in the keirs ought to be carried on in such a manner that the lye thoroughly penetrates the whole mass. If not, it may well happen that certain parts may be strongly heated without being impregnated with lye, and that the colouring principles are baked instead of being dissolved. This latter explanation appears to

<sup>1</sup> *Note by Translator.*—Real rosin soap, resinate of soda, is soluble in water; its colour varies with that of the rosin from which it is made. When such a soap comes in contact with a calcareous water, a precipitate of insoluble resinate of lime is formed, and fixed on the fibre. This precipitate is *at first* of a white colour, no matter how dark the original rosin; gradually, however, as it dehydrates it becomes yellowish brown, the depth of colour being equal to that of the original rosin. In other words, the white hydrated resinate masks the colouring principles, but, when dehydrated by steam drying, it adds to the colour of the fabric that of the rosin from which it was made. If the fabrics have been blued the green colouration is thus easily accounted for. The white resinate on air-dried fabrics dehydrates on storing or ageing, and the fabrics thus become yellow. The same remark applies to soap made from dark oils.

be deserving of consideration, because the author has found this yellowing to be especially prevalent in fabrics which have been boiled in Mather's keir, and as the fabrics are very tightly packed therein the lye does not always penetrate equally throughout.

*Damage caused by the Machines.*—These damages are not so serious as those due to the chemicals, because they are more readily seen, and it is more easy to find out the cause. The way to avoid them is to keep all plant and machinery used in bleaching in good working order; to inspect them frequently, and as soon as a flaw or mishap is observed to find out the cause and remedy it.' In describing the different machines, the mishaps which may occur in their working will be pointed out.

## CHAPTER XII.

### EXAMPLES OF METHODS USED IN BLEACHING.

**LINENS.**—*Light hand-spun Cambrics, etc.*—*Light Cambrics (machine-spun)*—*Cambrics, Cambric handkerchiefs (boiled yarn), Household linen*—*Cholet Cambrics and Cholet handkerchiefs in Cholet white*—*Fine linens and sheetings, full white*—*Coarse North of France or Normandy sheeting (cream yarn)*—*Ordinary white*—*Fine white*—*Three-quarters white*—*Half white*—*Sponging*—*Fine Cambric or Cholet handkerchiefs with coloured border, spun from half white yarn.*

**COTTONS.**—*Dry and swanskin Piqués*—*Calicoes, jaconets, nansouks*—*Embroidery*—*Piqués with stripes of different colours*—*Spongy fabrics with coloured borders*—*Spongy fabrics with red borders*—*Spongy fabrics without coloured borders.*

### LINENS.

#### *Light Hand-spun Cambrics, etc.*

1. Steep in hot water, twelve to twenty-four hours ; hand-wash ; squeeze.
2. First lye-boil, eight to ten hours, with salt of soda,  $1\cdot4^{\circ}$  to  $1\cdot6^{\circ}$  B., with rosin soap ; atmospheric pressure ; wash in keir ; squeeze.
3. Sour, hydrochloric acid in proportion of 5 litres to cubic metre ; temperature,  $27^{\circ}$  C. ; hand-wash ; squeeze.
4. Second lye-boil, same as first ; wash in keir ; squeeze.
5. Expose on bleaching green for twenty-four hours.



6. Wash in the stocks with olein soap and third lye-boil, same as second ; wash in keir ; squeeze.

7. Expose on the green twenty-four hours.

8. Wash with soap in stocks and fourth lye-boil, same as third.

9. Expose on bleaching green twenty-four hours.

10. Sorting out	{	First category—To be chemicked.
		Second category—Wash with soap in stocks, fifth lye-boil with salt of soda, and exposure on green.

11. First chemick, of 0·15 chlorometric degree ; temperature, 25° C. ; steep five hours ; hand-wash ; squeeze.

12. Sour, sulphuric acid ; 3 *litres* of acid per cubic *metre* ; temperature, 27° C. ; hand-wash ; squeeze.

13. Boil with olein soap, followed with lye-boil (salt of soda, 1·3° Baumé) ; wash in keir ; squeeze.

14. Expose on green for twenty-four hours.

15. Second chemick, of 0·1 to 0·12 chlorometric degree ; temperature, 25° C. ; steep five hours ; hand-wash ; squeeze.

16. Sour, sulphuric acid, same as after first chemick.

NOTE.—In summer the fabrics are very white. The second chemick is suppressed, and the fabrics are simply soured.

17. Lye-boil with salt of soda 1·3° Baumé, with olein soap.

18. Hand scouring in a bath of white soap or olein soap.

19. Sorting out	{	First category—Wash by running on hot water from above ; expose on green.
		Second category—Lye-boil with salt of soda 1° Baumé ; wash in keir and expose on green.

20. Sour, hydrochloric acid, in proportion of 4 *litres* per cubic *metre* ; temperature, 27° C. ; hand-wash ; squeeze.

21. Boil with olein soap, hand-rub.

22. Sorting out. A skilful workman, experienced in the treatment of these fabrics, will make several categories, give boilings with soap, slight lye-boils of  $0.5^{\circ}$  to  $1.0^{\circ}$  Baumé, hand rubbings, exposures on the green, but proceeds gently, so as not to destroy the fabrics. He ought to bring them to such a degree of whiteness that once they have received the third chemick no further operation should be necessary.

23. Third chemick, of  $0.08^{\circ}$  to  $0.01^{\circ}$  chlorometric degree ; temperature,  $25^{\circ}$  C. ; steep 3 to 4 hours ; hand-wash ; squeeze.

24. Sour, sulphuric acid, as after first chemick ; and wash very carefully. The pieces are sent to be finished.

REMARK I.—Light hand-spun cambrics ought to be washed by hand, because in washing them by the wash wheels, washing machines, or wash mills, these very highly-priced fabrics run the risk of being damaged

Especially is it the case when the fabric has not been closely woven ; the threads approach each other in an uneven manner, and there is no longer any regularity between the warp and the weft.

In order to wash the pieces the workman throws them into a tank of water. Holding them by one end he draws them out to their full length, then draws them back to himself and spins them out into the water again, repeating this manœuvre seven or eight times.

After each lye-boil the fabrics are washed in the keir before being spread out on the green. For this purpose the lye is run off and hot water run on to the fabrics, then cold water, until it runs away clear and colourless. Experience has shown that this method of washing is quite sufficient for fabrics which easily take up water before putting them on the grass, but it would not be effectual after chemicking or souring.

REMARK II.—*Lye-boiling*.—In the method of treatment prescribed, which yields very good results, the lyes are made

from beginning to end with salt of soda, 80 per cent. of carbonated and 20 per cent. of caustic alkali (soda). Another good method consists in making the lyes which precede the chemick with salt of soda of 1·8° Baumé, and those which follow the chemick with carbonate of soda three to four tenths of a degree Baumé stronger than those indicated for the salt of soda.

The fabrics are boiled under the atmospheric pressure ; the circulation of the lye is effected by a column at the bottom of which is a steam injector. If the keirs be of wrought or cast iron, it is desirable to line them in the interior with wooden staves, so that the fabrics do not get worn by rubbing against the sides.

REMARK III.—*Chemick and Sour*.—The use of hypochlorite of soda appears to us indispensable ; chloride of lime is not safe enough. The chemick baths and sour baths are made in wooden keirs at the temperature indicated, then the fabrics are packed in the bottom with a stick. The baths being feebler, they are run off after each operation, and the keirs filled with water for the first wash. It is important that the fabrics be well squeezed ; if not, the action of the chlorine and the acids, which are very weak, would be almost *nil*. If the fabrics have not been squeezed, the strength of the sours and the chemick must be increased.

REMARK IV.—*Sorting out*.—The assorting of the fabrics, especially towards the end, requires a very skilful and experienced workman. The number varies in consequence of the difference in the yarns which have been used in the weaving of the fabrics treated. The end of these assortments is to bring all the fabrics to the same degree of whiteness by gentler methods, so as not to injure them in the process.

REMARK V.—The author made experiments to ascertain whether the process of hand washing could not be suppressed, and found that it could not. Without it the whites obtained were neither so bright nor so brilliant.

*Light Cambrics (Machine-spun).*

These fabrics are not so fine and do not require to be handled so delicately; but as the warp and the weft are not tightly woven, care must be taken in the washing not to unweave the fabric.

1. Steep in hot water; hand-wash; squeeze.
2. First lime-boil or buck, in the proportion of 6 lb. of lime per 100 lb. of fabrics, 6 hours; boiling temperature; wash in the dash wheel; squeeze.
3. Sour, hydrochloric acid, 5 *litres* per cubic *metre*; temperature, 27° C.; hand-wash; squeeze.
4. Second lye-boil, with salt of soda, 1·6° Baumé, with rosin soap; wash in the keir; squeeze.
5. Spread on the bleaching green for 24 hours.
6. Wash with soap on the rubbing boards, and third lye-boil, with salt of soda, at 1·6° Baumé; wash in keir; squeeze.
7. Spread on green for 24 hours.
8. Fourth lye-boil, with salt of soda, 1·6° Baumé, with rosin soap; wash in keir; squeeze.
9. Spread on green for 24 hours.
10. Assortment  $\left\{ \begin{array}{l} \text{First category—Chemick.} \\ \text{Second category—Lye-boil with salt} \\ \text{of soda of 1·6° Baumé.} \end{array} \right.$
11. First chemick, at 0·15° chlorometric; temperature, 25° C.; steep 6 hours; hand-wash fine pieces, more common pieces to the wash mill; squeeze.
12. Sour, sulphuric acid in the proportion of 3 *litres* per cubic *metre*; temperature, 27° C.; wash as after chemick; squeeze.
13. Boil with olein soap and lye-boil with salt of soda at 1·3° Baumé; wash in keir; squeeze.
14. Spread on green for 24 hours.
15. Second chemick, at 0·10° chlorometric; temperature, 25° C.; steep 6 hours; wash as after first chemick.

16. Sour as after first chemick.
17. Boil with olein soap ; lye-boil with salt of soda at  $1\cdot3^{\circ}$  Baumé ; wash in keir.
18. Spread on the green for 24 hours.
19. Sour, hydrochloric acid in proportion of 5 *litres* per cubic *metre* of water ; temperature,  $27^{\circ}$  C. ; hand-wash or wash mill ; squeeze.
20. Boil with olein soap and lye-boil with salt of soda at  $1\cdot3^{\circ}$  B. ; wash in keir ; squeeze.

21. Assortment	{	First category—Spread on green.
		Second category—Lye-boil with soda of $1\cdot3^{\circ}$ Baumé and spread on green.

22. Sour, hydrochloric acid in proportion of 5 *litres* per cubic *metre* of water ; temperature,  $27^{\circ}$  C. ; wash ; dry.

23. Assortment. According to the degree of whiteness the fabrics are soap-boiled, lye-boiled, and spread on the green. It falls to the workmen entrusted with the treatment of the fabrics to regulate the number and the intensity of the treatments. A passage through the stocks, followed by a good washing with hot water, answers very well for the last operation before the final chemick.

24. Third chemick,  $0\cdot08^{\circ}$  to  $0\cdot10^{\circ}$  chlorometric ; temperature,  $25^{\circ}$  C. ; steep four hours ; wash ; squeeze.

25. Sour, sulphuric acid, as after the first chemick ; wash very carefully by hand or the dash wheel.

Send to be finished.

REMARK I.—The remarks made at the end of the treatment of the hand-spun apply equally to the fabrics made from machine-spun yarn.

REMARK II.—*Lyes*.—The lyes which precede the chemick may well be increased to  $1\cdot8^{\circ}$  Baumé and those which follow it, of carbonate of soda of  $1^{\circ}$ , vary from  $1\cdot3^{\circ}$  to  $1\cdot8^{\circ}$  Baumé. To diminish the labour and economise soap, the author has



suppressed the boilings with soap preceding the lye-boilings, and added a little more soap in the lyes. This modification did not diminish to any appreciable extent the perfection of the whiteness.

REMARK III.—*Chemicks and Sours*.—If the chemick liquor be employed cold, and the fabrics be not squeezed, the baths may be made of the following strengths :—

First chemick	;	-	-	-	0°60°	Steep 3 hours.
Second chemick	-	-	-	-	0°40°	„ 3 „
Third chemick	-	-	-	-	0°30°	„ 3 „

In the same way, if the sours be cold they are made of 0°5° Baumé.

*Cambrics, Boiled Yarn Cambric Handkerchiefs, Household Linen (Blanc de Ménage).*

1. Lime-boil ten hours with 10 per cent. of lime on weight of fabrics ; wash in stocks.

2. Sour, hydrochloric acid, 2° Baumé ; temperature of bleaching room ; wash in stocks.

3. Lye-boil ten hours, with salt of soda, 3¼° Baumé, with rosin soap ; temperature, 112° C. ; wash in keir. The fabrics are not taken out of the keir, and are lye-boiled a second time in the same way as the first ; wash in stocks.

4. Spread on green two or three days.

5. Lye-boil ten hours with salt of soda, 2° Baumé, with rosin soap ; temperature, 112° C. ; wash in stocks.

6. Spread on green for two or three days.

7. Lye-boil with salt of soda as in 5.

8. Spread on green two or three days.

9. First chemick at 0°65° chlorometric temperature of bleaching room ; steep three hours ; wash in stocks.

10. Sour, sulphuric acid, 1° Baumé ; temperature of bleaching room ; wash in stocks.

11. Scour with soap in wash mill or on rubbing boards ;

lye-boil six hours, with carbonate of soda,  $1^{\circ}$  Baumé; boiling temperature; wash in wash mill.

12. Spread on green for two days.

13. Second chemick and sour same as first.

14. Same as 11.

15. Third chemick and sour same as first.

16. Double washing in the dash wheel, after which the fabrics are sent to be finished.

The pieces which are not white enough are soaped or lye-boiled, or only chemicked and soured.

REMARK I.—In this process the fabrics are boiled with strong lyes before the chemick, and with weak lyes afterwards. A very bright white is thus obtained, and the soundness of the fabric is to a great extent preserved.

REMARK II.—The three chemicks have the same strength. Experience has shown that no mishap occurs by working in that way, and it is easier for the workman who prepares the chemick.

*Cholet Cambrics and Cholet Handkerchiefs in Cholet White.*

1. Lime-boil, ten hours, with 8 per cent. of lime on weight of fabrics; boiling temperature; wash in stocks.

Unbleached cloth and brown holland are put in the lime-boil dry; cream linen is first steeped in hot water and washed before lime-boiling.

2. Sour, hydrochloric acid,  $2^{\circ}$  Baumé; temperature of bleaching room; steep six hours; wash in stocks.

3. Lye-boil, ten hours, with salt of soda,  $1.8^{\circ}$  Baumé, and made in proportion of 6 per cent. of salt on weight of fabrics; temperature,  $110^{\circ}$  C.; wash in keir. The fabrics are not taken out, but are lye-boiled a second time in the same way as before, but with a slightly weaker lye, say  $1.5^{\circ}$  Baumé, and made in the proportion of 5 per cent. of salt on the weight of fabrics; wash in stocks.

4. Spread on green for three days.
5. Lye-boil with salt of soda, 1.5° Baumé, or 5 per cent. on the weight of the fabrics ; wash in stocks.
6. Spread on green for three days.
7. First chemick, at 0.65 chlorometric degree ; temperature of room ; steep three hours ; wash in stocks.
8. Sour, sulphuric acid, at 1° Baumé ; temperature of room ; wash in stocks.
9. Wash with olein soap on the rubbing boards, etc. ; lye-boil, eight hours, with salt of soda at 1° Baumé, in proportion of 3 to 4 per cent. of salt on weight of fabrics ; boiling temperature ; wash in stocks.
10. Spread on green for three days.
11. Second chemick and sour, same as first.
12. Assortment. Those which are not sufficiently white receive another scrubbing with soap on the rubbing boards, the others are lye-boiled directly with the former ; lye-boil, six hours, with salt of soda of 0.8° to 1° Baumé, with olein soap ; boiling temperature ; wash in stocks.
13. Spread on green for three days.
14. Third chemick, at 0.45° chlorometric ; temperature of room ; steep three hours ; wash in stocks.
15. Sour, as after first chemick ; double wash in stocks, or, better, one wash in stocks and one in dash wheel ; send to be finished. If the fabrics be not white enough they are scoured with soap on the rubbing boards, boiled with weak lye, spread on the green, chemicked and soured.

*Fine Linens and Sheetings (Full White).*

In this category are included fine white cambrics, Irish and Cambray linen.

It is difficult to prescribe the number of processes to which they should be subjected. That depends on the nature of the fabrics to be bleached and the quality of the yarn of which

they are composed, and also upon the nature of the plant at the disposal of the bleacher. Thus open keirs do not act so energetically as closed keirs, in which the fabrics are lye-boiled at a higher temperature. A lye which circulates through the fabrics has more effect than a stationary lye. If very strong caustic lyes be used, fewer lye-boilings will be required than if they contained much carbonated and but little caustic alkali (soda). Practice has indicated the proportions in which the carbonate of soda and the caustic soda should be mixed, and the strength of the lyes made therefrom which are best adapted for the kind of fabric about to be treated.

As a starting-point, reference should be made to what has been said in the examples of different processes to ascertain what method to pursue according to the results obtained.

The following are the principles of the methods adopted in Ireland, and from which it is advisable not to depart:—

1. *Chemicking of the Fabrics.*—The most important of all is not to chemick the fabrics until after they have reached a certain stage of brightness and whiteness, so that they may be at once completely bleached by the use of but a weak chlorine steep, etc. Experience has proved that if the fabrics are chemicked too soon—that is to say before they have been sufficiently lye-boiled—it is almost impossible to bring them to a fine, beautiful white.

The reason of this is not capable of being very satisfactorily explained; it may arise from the fact that the chlorine transforms certain bodies into more difficultly soluble substances, which the lye is unable to further dissolve in the subsequent operations. Experience has also shown that fabrics which have been chemicked no longer withstand the action of such strong lyes as previous thereto, and become more tender and attenuated under the action thereof.

In winter spreading on the green does not contribute to

the bleaching to the same extent as in summer, and its action is slower.

For these reasons a very careful examination and assortment should be made, and all the cloths which are not sufficiently white should be re-boiled and "grassed" as often as need be.

The following figures, published by Dr. Andrews, of Belfast, which give a six years' summary of the operations of the Milltown Bleach Works, Bambridge, bring this fact out very prominently :—

AVERAGE OF LYE-BOILS BEFORE AND AFTER THE CHEMICK  
FOR SIX YEARS, AND AVERAGE NUMBER OF DAYS'  
DURATION OF TREATMENT.

Months.	Number of lye-boils before Chemick.	Number of lye-boils after Chemick.	Total Number of lye-boils.	Number of days under treatment.
January - -	4'33	4'27	8'60	62'7
February - -	4'29	4'01	8'30	58'25
March - -	4'03	3'68	7'71	53'42
April - -	3'66	3'70	7'36	49'35
May - -	3'68	3'64	7'32	46'33
June - -	3'74	3'60	7'34	43
July - -	3'70	3'48	7'18	41
August - -	3'83	3'39	7'22	47
September - -	4'10	3'87	7'97	46'29
October - -	4'35	4'19	8'54	48'83
November - -	4'48	4'74	9'22	56'41
December - -	6'89	4'45	11'34	61'25

It therefore appears advisable in the winter months of November, December, January and February to give heavy linen as a minimum five lye-boils and five spreadings on the green, and four lye-boils and four spreadings on the green during the rest of the year, and to give light fabrics four lye-boils and four spreadings on the green during winter, and three lye-boils and three spreadings on the green during summer.

The lye-boils before the chemick should be made from a mixture of caustic and carbonated alkali—20 of caustic to 80



of carbonated alkali (soda). The strength of the lyes should gradually diminish in proportion as the bleaching process progresses.

The following strength may be used :—

Lye-boil.	Summer.	Winter.
	Degrees Baumé.	Degrees Baumé.
1	2'5	2
2	2	2
3	2	1'5
4	1'5	1'5
5	1'5	

2. *Chemicking of Heavy Linens.*—There would appear to be no benefit to be derived from making an assortment before the chemick, so as to give a stronger chemick to the heavier linens. In fact the heavier linens are those which are most liable to soften under the treatment, and which are the most difficult to bleach, and entail the oft-repeated application of gentle operations. It must no longer be believed that strong chemicks greatly promote the progress of bleaching. Chemicks of medium strength must be used, and these strengths have been determined by experience.

The author, therefore, recommends the following :—

Chemick.	Hot Chemick.		Cold Chemick.	
	Chlorometric Degree.	Duration.	Chlorometric Degree.	Duration.
1	0'20	7 hours	0'60	3 hours
2	0'15	7 "	0'40	3 "
3	0'15	6 "	0'30	3 "
4	0'10	4 "	0'25	3 "
5	0'10	4 "	0'20	2 "

It will be seen from this table that hot chemicks are much more energetic than cold.

Care must be taken when steeping the goods in the chemick that they are thoroughly and equally impregnated

throughout with the bleaching liquor, otherwise unequal bleaching will result. It would appear to be necessary to "reel" the fabrics into the first, second and third chemick.

Care must be taken not to multiply the chemicks too many times. Accordingly, before the fourth chemick, an experienced workman decides whether or not the fourth chemick will render the fabrics white enough to be "finished" immediately afterwards. If he does not think so, he gives the fabrics a soaping and a weak lye boil—two if need be—and he thus brings them so far forward in the bleaching that the fourth chemick is the last operation. A fifth chemick should be the exception.

3. *Carbonate of Soda Lyes.*—When the fabrics have been well lye-boiled before the chemick, the lyes which follow may very well be made from carbonate of soda (Solvay) without any addition of caustic soda. The advantage consists in being able to work with greater assurance of safety, and in having no fear that the soundness of the fabrics may be weakened. Certain bleachers, however, find that carbonate of soda alone does not forward the progress of the bleaching to the extent desired, and prefer to use salt of soda from beginning to end of the operation.

The strength of the lyes preferred by the author, whether consisting of carbonated alkali alone or of a mixture of caustic and carbonated alkali (salt of soda), are as follows:—

Lye-boil	Solvay Carbonate of Soda (Soda Ash).	Salt of Soda—20 per cent. Caustic, 80 per cent. Carbonate.
	Degrees Baumé.	Degrees Baumé.
After 1st Chemick - -	2	1'5
After 2nd Chemick - -	1'5	1'2
After 3rd Chemick - -	1	0'8
After 4th Chemick - -	1	0'6 to 0'7

4. *The Soap Bath.*—After the sours which follow the first, second, and even the third chemick, it is very advisable to

wash the fabrics with soap on the rubbing boards or in the stocks. As this soaping follows the sour, it is advisable to add carbonate of soda and even caustic soda to the soap bath, so as to neutralise the acid and hinder the decomposition of the soap. This is the reason why every scouring with soap is followed by lye-boiling, however slight it may be. In fact as the soaping follows the acid, there is always a little decomposed soap, and neither washing in the ordinary way with cold water nor even with hot water in the keir will remove the liberated fatty acid adhering to the fibres of the fabric.<sup>1</sup> It must be saponified afresh by alkaline lye, however weak it may be. The fabrics are then washed and submitted to the final chemick, without spreading them on the green. This last exposure on the bleaching green has but little bleaching effect, and in bad seasons the fabrics are often soiled or damaged. Consequently, they are not spread on the green any further after the third chemick, and the bleaching process is completed in the works.

5. *Washing and Squeezing*.—Washing with the machine is the most economical, but it is to be feared that the water does not penetrate into the interior of the folds, and only washes on the surface. The washing which precedes the spreading on the green is best done in the wash mills or wash wheels. In washing with the wash mills the water penetrates into the interior of the fabrics, and is expressed by the compression of the hammer, but, as the fabrics are always in parcels, the dirt, such as dust, leaves, mud from the green, is not removed. In this case washing with the machine or the dash wheel must be resorted to. The wringing, which consists in squeezing or pressing out the wash water, is an excellent operation, because the fabrics are then more apt to benefit to the full extent by the succeeding process.

<sup>1</sup> See note, p. 139. This precipitated fatty acid plus dark rosin will eventually, in dehydrating, yellow the fabrics if not removed.—Tr.

If hot chemicks and hot sours be used of the strengths previously indicated, the wash water must unquestionably be wrung out, or at least allowed to drain or drip off. The strength of these chemicks and sours is very weak ; nevertheless, they are sufficiently strong if the fabrics be well wrung, but they are not so if the fabrics are impregnated with water.

6. *Inspection*.—When valuable linen is being bleached it is advisable to stretch it from time to time during the whole course of the bleaching operations. A workman is deputed to examine it, and to report any damage which he may find. The cause is at once sought, and the damage prevented from spreading.

These observations have led to the adoption of the following course of operations :—

1. Lime-boil ; wash ; sour ; wash.
2. Lye-boil with salt of soda ; wash.
3. Spread on green.
4. Lye-boil with salt of soda ; wash.
5. Spread on green.
6. Lye-boil with salt of soda ; wash.
7. Spread on green.

- |               |   |  |
|---------------|---|--|
| 8. Assortment | { | First category—To chemick.   |
|               |   | Second category—Lye-boil with salt of soda ; wash ; spread on green. |

9. First chemick ; wash ; sour ; wash.
10. Scour with soap on rubbing boards ; lye-boil with carbonate or salt of soda ; wash.
11. Spread on green.
12. Second chemick ; wash ; sour ; wash.
13. Same as 10.
14. Spread on green.
15. Third chemick ; wash ; sour ; wash.
16. Assortment. Those fabrics white enough are sent to be finished ; the others are further treated as follows :—

17. Wash in stocks with soap ; slightly lye-boil ; wash. They are then examined to ascertain if fit for fourth chemick. If not, they are given a fresh rubbing with soap and a fresh lye-boil.

18. Fourth chemick ; wash ; sour ; wash.

19. If the fabrics are not even now white enough to be finished, they are given a scouring with soap and a lye-boil, followed by washing.

20. Fifth chemick ; wash ; sour ; wash.

*Coarse North of France (du Nord) or Normandy Sheeting,  
Woven from Cream Yarn.*

These linens are much more delicate to bleach than finer fabrics, because they are more impervious to chemical reagents, and also because it is, moreover, very difficult to wash them thoroughly after each operation. They are therefore treated with weak lyes and long exposures on the green. By the following methods the fabrics preserve their soundness to a great extent, but by giving them very thorough washing they may be treated more energetically and yet be sound enough, whilst at the same time a prettier white is obtained.

*Ordinary White (Blanc Ordinaire).*

1. Steep in hot water for twelve to twenty-four hours ; wash in machine.

2. First lye-boil, eight hours, with salt of soda in proportion of 3 per cent. on weight of fabrics ; the lye marks  $0.8^{\circ}$  to  $1^{\circ}$  Baumé ; temperature not to exceed  $90^{\circ}$  to  $95^{\circ}$  C. ; wash in machine.

3. Spread on green for five or six days.

4. Second lye-boil, with salt of soda in proportion of 2 per cent. of salt on weight of fabrics ; operation conducted same as in first lye-boil ; wash in machine.

5. Spread on green five days.

6. First chemick, at  $0.75^{\circ}$  chlorometric ; temperature of



bleach works ; steep four to five hours. In winter it is advisable to heat the chemick to  $20^{\circ}$  C. ; wash in machine.

7. Sour, sulphuric acid,  $1^{\circ}$  Baumé ; temperature of the bleach works ; wash in machine.

8. Lye-boil six hours with salt of soda in proportion of  $1\frac{1}{2}$  per cent. of salt on weight of fabrics ; wash in machine.

9. Spread on green five days.

10. Second chemick, at  $0.75^{\circ}$  chlorometric ; steep four hours ; wash in machine.

11. Sour, sulphuric acid,  $0.5^{\circ}$  Baumé ; temperature of bleach works ; wash in machine.

12. Lye-boil six hours with salt of soda in proportion of 1 per cent. of salt on weight of fabrics ; temperature,  $60^{\circ}$  C.

13. Third chemick, at  $0.5^{\circ}$  chlorometric strength ; temperature of the bleach works ; wash in machine.

14. Sour, sulphuric acid, at  $0.5^{\circ}$  Baumé ; temperature of the works ; wash in machine.

15. Soap, boil six hours with 3 parts by weight of soap and 2 parts by weight of salt of soda per 1,000 parts by weight of fabrics ; temperature,  $60^{\circ}$  C.

A little indigo is put in this lye so as to impart a bluish tint to the fabrics, a tint which they retain much better than that of the blue applied to them in the finishing process.

Wash in stocks ; send to be finished.

#### *Fine White (Beau Blanc).*

The operations are the same as those for ordinary linen white. In addition, the fabrics receive after the third chemick a lye-boil and an exposure on the green, and a fourth chemick.

#### *Three-quarters White.*

Same operations as for ordinary linen white, but no further than the sour after the second chemick, when they receive the final soaping and are sent to be finished.

*Half White (Cream).*

These cloths receive a chemick at 1° chlorometric strength, into which they are put dry as they come from the warehouse. Steep three to four hours; wash in stocks; give a second chemick at 0.75° chlorometric strength; sour, and give the final soaping, with blue, before sending to be finished.

*Sponging (Décatissage).*

Boil with soap lye; wash and send to be finished.

*Fine Cambric or Cholet Handkerchiefs with Coloured Border,  
Woven from Half White Yarn.*

1. Steeping. To strip the fabrics of surface impurities they are passed through a double washing machine. The tank of the first machine contains hot water at 50° C., whilst cold water circulates in the other.

2. Lye-boil in the double washing machine. The two tanks contain lye of 1° Baumé kept at a temperature of 50° C. Wash in washing machine.

3. Spread on green for two days.

4. Lye-boil six hours in keir, with carbonate of soda, 2° Baumé; temperature, 65° C.; or lye-boil six hours with carbonate of soda, 1° Baumé; temperature, 75° to 80° C.; wash in washing machine or wash mills.

5. Spread on green for two days.

6. Repeat the lye-boils and exposures on the green as many times as are required to bring the fabrics to the degree of whiteness aimed at, and as far as the durability of the fabric will permit of this being done. In order to produce a full white the handkerchiefs receive five lye-boils in the keir and six spreadings on the green before being chemicked. The operations are conducted so as to give the fabrics all the necessary lye-boilings before the chemick, which ought to be

single, because once they have been chemicked the colour is much more easily attacked by the alkaline lye.

7. Chemick,  $0.20^{\circ}$  to  $0.25^{\circ}$  chlorometric strength; temperature of works; steep three hours; reel twice in the tank; wash twice in the washing machine or wash mills.

8. Pass through oxalic or acetic acid in the double washing machine. The tank of the first machine contains acid, whilst water in the other is kept constantly renewed. This first washing should be followed by a second in the washing machine or in the dash wheels or wash mills.

9. Assortment. After the chemick the fabrics are assorted. Those which are white enough are sent to be finished, whilst the others receive a slight lye-boil, a spread on the green, and a chemick at  $0.15^{\circ}$  chlorometric strength.

*Remark I.*—The double washing machine referred to is described in Chapter III. It is very convenient for treating with feeble lyes. A steam-pipe is then placed under the false bottom to heat the water or the lye. As a washing machine it enables two washings to be given to the goods simultaneously without extra labour.

*Remark II.*—It is well to commence by treating the fabrics with alkaline lye in the washing machine, because the colour then discharges itself without soiling the inner margin of the fabrics, as would be the case if the first lye-boil was given in the ordinary keir.

*Remark III.*—Coloured fabrics may be lye-boiled in a keir where the circulation of the lye is effected by a Koerting injector. But the circulation must be intermittent, so as not to exceed a temperature of  $65^{\circ}$  C. The fabrics should not be too strongly packed in the keir; the lye is run in first, and the fabrics are afterwards piled therein by the aid of a stick. This mode of packing has the inconvenience of only allowing a small quantity of fabrics to be put into a keir at a time. It is better to use a keir where the circulation of the lye is effected

by a centrifugal pump. As the circulation in that case is made independently of the steam introduced for heating purposes, it may be made as energetic as desired, whilst at the same time the lye is maintained at a constant temperature. In this case the pieces are piled in the keir and lashed or pressed down, and the lye is then run on them from above. Thus in a keir of the same capacity a great many more pieces may be stowed than in the former case.

*Remark IV.*—For coloured fabrics carbonate of soda alone is generally used, but if very good colours are to be treated a little caustic soda and soap may be used. If the colours have but little resistance the lyes should not be too strong nor the temperature too high. The author has observed that a lye of 1° Baumé, heated to 80° C., produced the same effect as a lye of 65° C. and 2° Baumé. The circulation of the lye is made by a centrifugal pump.

*Remark V.*—In summer the sun discharges certain colours. It is advisable to take them in when the sun is too hot, or to cover them well with other fabrics. When the fabrics come off the green soiled with mud they must be washed before being lye-boiled, because the lye bakes the mud, and it is much more difficult to remove afterwards.

*Remark VI.*—After the chemick the fabrics are not soured with sulphuric or hydrochloric acid for fear of weakening the colour ; only a weak acid is used, such as oxalic acid.

*Handkerchiefs with Coloured Borders (another method).*

1. Steep in warm water, 25° C. ; wash.
2. Steep in soap bath for two hours at a temperature of 25° C.
3. Spread on green two days.
4. Lye-boil six hours with carbonate of soda, 2° Baumé ; temperature, 65° C. ; wash.
5. Spread on green two days.

6. Steep in a bath of soap ; wash.
7. Spread on green two days.
8. Lye-boil six hours with carbonate of soda at 2° Baumé ; temperature, 65° C. ; wash.
9. Spread on green two days.

10. Assortment. Put on one side the fabrics white enough to go to the chemick, and send the others to be lye-boiled, and spread on the green.

11. Chemick, chlorometric strength 0·2° to 0·5° ; temperature of the works ; steep three hours ; reel twice ; wash.

12. Sour, oxalic acid, as indicated in previous treatment. The author may remark that the souring with oxalic acid may be dispensed with provided that the chemick has been followed by thorough and effectual washing.

13. Assortment. Place on one side the fabrics which are white enough to be finished, and on the other those which require a lye-boil, a spread out on the green, and a chemick.

*Remark I.*—The soap bath for steeping is made in the proportion of  $3\frac{1}{3}$  kilogrammes of Marseilles soap per cubic metre of water. The same bath may be used two or three weeks ; it is run away when it smells too badly. Every five days 500 grammes of soap are added to replace the soap absorbed by the fabrics. The temperature should not exceed 25° C., so that the soap does not attack the colours.

*Remark II.*—So as to preserve the colours as far as possible, no soap is added to the lye. If the colours are good, the use of soap, provided it be not caustic, will not be the cause of any danger, and will help to render the action of the lye more energetic.

If the circulation of the lye be not effected by a pump, and consequently is very slow, the fabrics must be stowed in the lye in such a manner as not to be crushed, otherwise the result of the lye-boiling will be very unequal.



## COTTONS.

*Piqués Secs and Piqués Molletonnés.*

1. Lime-boil ten hours, 10 per cent. of lime on weight of fabrics ; boiling temperature ; wash in washing machine.

2. Sour, hydrochloric acid, 2° Baumé ; temperature of works ; steep at least six hours ; wash in washing machine.

3. Lye-boil ten hours with salt of soda at 3° Baumé, in proportion of 10 per cent. of salt on weight of fabrics, with the addition of rosin soap ; temperature, 110° C. ; wash in the keir, followed by a second lye-boil under the same conditions as the first ; wash in washing machine.

4. First chemick, chlorometric strength 110° ; temperature of the works ; steep three hours ; wash in washing machine.

5. Sour, mixture of 7 litres of sulphuric acid with 4 litres of hydrochloric acid per cubic metre of water, 0.8° Baumé, six hours ; temperature of works ; wash in washing machine.

6. Lye-boil eight hours with carbonate of soda of 1.5° Baumé, made in the proportion of 5 per cent. of carbonate of soda and 1 per cent. of Marseilles soap on the weight of fabrics ; temperature, 110° C. ; wash in washing machine.

7. Second chemick, same as first ; wash in washing machine.

8. Sour, same as after first chemick.

The fabrics are then washed twice in washing machine and sent to be finished.

*Remark I.*—This method gives a very beautiful white, whilst at the same time the fabrics retain much of their strength.

*Remark II.*—The lye-boils are imparted in closed keirs, under pressure, and the circulation is effected by a centrifugal pump throughout the whole of the lye-boil.

*Remark III.*—The fabrics are chemicked and soured in such a manner that they are thoroughly impregnated through-

out their entire mass. Whilst the fabrics are being delivered into the chemicking and souring tanks, the chemick or the sour is pumped in at the same time. A man, shod with india-rubber boots, tramps down the fabrics. The fabrics may also be steeped by immersing them in the liquid by means of a stick. In the latter case a much smaller quantity can be packed in the same tank.

✓ *Calicoes, Jaconets, Nansouks.*

1. Steep in hot water ; wash.
2. First lye-boil, ten hours, with salt of soda, 2° Baumé, with olein soap ; temperature, 110° C. ; wash.
3. Second lye-boil, same as first ; wash in keir.
4. Assortment { First assortment—Chemick.  
Second assortment—Lye-boil as before.
5. First chemick, chlorometric strength of 0·15° to 0·20° ; temperature, 25° C. ; steep five to six hours ; wash and wring.
6. Sour, 3 litres of acid to 1 cubic metre of water ; temperature, 27° C. ; wash and squeeze.
7. Lye-boil, six hours, with carbonate of soda, at 2° Baumé, with Marseilles or olein soap ; boiling temperature ; wash in keir.
8. Second chemick, chlorometric strength 0·15° ; temperature, 25° C. ; steep five to six hours ; wash ; squeeze.
9. Sour, sulphuric acid, same as after first chemick.
10. Assortment { First assortment—Finish.  
Second assortment—Lye-boil ; chemick ; finish.

*Remark I.*—The method of washing has not been given after each operation. Washing in the washing machine is more rapid and economical than by the wash wheels ; it has the disadvantage of not penetrating the tissues and opening the grains. The author therefore advises, wherever practicable, to wash by the dash wheel.

*Remark II.*—The chemicks and sours indicated require to be warmed, and to produce a good effect the fabrics should have previously been well squeezed. If cold chemicks and sours be used, and the fabrics be not squeezed, they should be of the following chlorometric strength:—

First chemick	-	-	-	-	-	-	-	0·65°
Second chemick	-	-	-	-	-	-	-	0·50°
Third chemick	-	-	-	-	-	-	-	0·30°

The sours are made of density of 0·7° Baumé.

It is not necessary to wash by the machine the fabrics as they come from the lye to go to the chemick; a wash in the keir suffices.

If the fabrics retain a little lye it renders the chemick a little more alkaline, and its bleaching action slower. The yellow tint of the fabrics as they come from the chemick disappears in the sour.

#### *Embroidery.*

1. Steep in hot water; wash in wash wheel; wring.
2. Lime-boil eight hours in proportion of 6 per cent. of lime on weight of fabrics; boiling temperature; wash; wring.
3. Sour, hydrochloric acid, 0·5° Baumé; temperature, 27° C.; wash; wring.
4. Lye-boil, eight hours, with salt of soda, 2° Baumé, with olein soap; temperature, 110° C.; wash; wring.
5. Wash the strongest and darkest pieces in the stocks with soap; send the others direct to the lye-boil. Lye-boil with salt of soda the same way as in No. 4; wash in keir.
6. Assortment
 

{	First assortment—Chemick.
	Second assortment—Wash in stocks with soap; lye-boil with salt of soda
	1·5° Baumé; chemick.
7. First chemick, chlorometric strength 0·2°; temperature, 25° C.; steep five hours; wash; wring.

8. Sour, sulphuric acid 3 *litres* per cubic *metre*; temperature,  $27^{\circ}$  C.; wash; wring.

9. Soap in stocks with olein soap; lye-boil, eight hours, with carbonate of soda,  $2^{\circ}$  Baumé; boiling temperature; wash in keir.

10. Second chemick, chlorometric strength  $0.15^{\circ}$ ; temperature,  $25^{\circ}$  C.; steep four hours; wash; wring.

11. Sour as after first chemick; wash; wring.

12. Assortment	{	First assortment—Finish.
		Second assortment—Chemick.
		Third assortment — Lye - boil with
		carbonate of soda at $1.5^{\circ}$ Baumé,
		and chemick.

13. Third chemick, chlorometric strength  $0.1^{\circ}$ ; temperature,  $25^{\circ}$  C.; wash; wring.

*Remark I.*—All the washings are done by the dash wheel; if the fabrics be too fine they are hand-washed.

*Remark II.*—The chemicks and sours indicated are heated. If applied in the cold, the operations must be conducted as prescribed in Remark II. following the treatment of calicoes (p. 164).

*Piqués with Stripes of Different Colours.* ✓

1. Steep in tepid water; wash.

2. Lye-boil three or four times with carbonate of soda; wash between each lye-boil. If the colours be delicate the pieces are reeled in the lye to prevent the colour from depositing.

3. First chemick, chlorometric strength  $0.3^{\circ}$ ; temperature of works; steep three hours; reel; wash:

4. Second chemick at  $0.2^{\circ}$  chlorometric strength; temperature of the workshop; steep three hours; reel; double wash and send to be finished.

*Remark I.*—The strength of the lyes and sours ought to

be proportioned to the resistance of the colour to be treated. Experience alone will guide the bleacher and instruct him as to what operations are suitable for certain colours and not for others.

*Remark II.*—The lyes are carbonate of soda lyes of 2° Baumé. The temperature varies from 65° to 70° C. The keirs are surmounted by a winder or reel, and the pieces are successively rolled round this reel or winder, and then unrolled into the lye. In this manner the fabrics are continually on the move, and if the colour be dissolved out it is carried away by the lye and does not stain the fabrics.

*Spongy Fabrics with Borders of Various Colours.*

The treatment of these depends on the resistance of the colours. They are treated like colour-striped piqués. The following operations are generally sufficient:—

1. Steeping by passing the fabrics through the double washing machine. The tank of the first machine contains water heated to 50°, and the water in the second tank is cold water unceasingly renewed, *i.e.*, ingress and egress taps are kept running.
2. Lye-boil once or twice in the double washing machine, with carbonate of soda lye of 1° to 2° Baumé, at a temperature of 65° C.
3. First chemick, chlorometric strength 0·30°; temperature that of works; steep two to three hours; reel; wash in washing machine.
4. Second chemick, chlorometric strength 0·20°; temperature that of works; steep two to three hours; reel; double wash in washing machine.
5. Pass to blueing in double washing machine as indicated for spongy fabrics with red borders.



*Spongy Fabrics with Red Borders (Napkins, Towels, Bath Towels, etc.).*

The author does not recommend this treatment to be applied to fabrics the colour of which is not fast and persistent; but red is not altered by a slightly caustic lye.

1. Steep in warm water of 30° C.; wash in washing machine.

2. Lye-boil, eight hours, with salt of soda, 1·2° Baumé; boiling temperature; wash in washing machine.

3. Same as 2.

4. First chemick, chlorometric strength 0·60°; temperature of works; steep three hours; reel twice; wash in washing machine.

5. Sour with sulphuric acid, 2 litres to the cubic metre of water, in double washing machine. The tank of the first machine contains the acid, and the second the water, which is continually renewed.

6. Second chemick, chlorometric strength 0·50°; temperature of works; steep three hours; wash twice with washing machine.

7. The fabrics are blued without being finished. For this purpose a washing machine the tank of which contains the blue is very convenient. A little soap is added to impart softness to the fabrics.

*Spongy Fabrics without Coloured Borders.*

These fabrics are treated in the same way as those with a coloured border, but as discolouration is not to be feared the lye may be made of salt of soda at 2° Baumé instead of 1·2° Baumé; then after the chemick they are soured in the ordinary way.

Moreover, these fabrics are very easily bleached, only care must be taken that they are not spotted by the lye; this happens when they are pressed too tightly in the keir.

## CHAPTER XIII.

### THE VALUATION OF CAUSTIC AND CARBONATED ALKALI (SODA) AND GENERAL INFORMATION REGARDING THESE BODIES.

*Object of Alkalimetry—Titration of Carbonate of Soda—Comparative Table of Different Degrees of Alkalimetric Strength—Use of Di-methyl Orange as an Indicator in Place of Litmus—Titration of Weak Carbonate of Soda Lyes—Five Problems relative to Caustic and Carbonated Alkali (Soda)—Composition of Solvay Soda Ash; Caustic Soda, its Properties and Uses—Solution of Caustic Soda—Titration of Caustic Soda—Titration of a Mixture of Carbonated and Caustic Alkali (Soda)—Mixtures of Carbonated and Caustic Alkali—Note on a Process for Manufacturing Caustic Soda and Mixtures of Caustic and Carbonated Alkali (Soda)—Determining the Duration of the Useful Employment of Lyes; their Revivification.*

*Object of Alkalimetry.*—The object of alkalimetry is to ascertain the strength of any soda lye. In France soda is generally valued by the Descroizilles degree. The Descroizilles degree represents the number of parts by weight of monohydrated sulphuric acid which can be neutralised by 100 parts of the sample to be tested.

#### *Titration of Carbonate of Soda.*

The following instructions in regard to the titration of carbonate of soda are taken from a notice by Solvay & Co.

Pure carbonate of soda  $\text{Na}_2\text{CO}_3$  titrates  $92.45^\circ$  Descroizilles,

that is, 100 parts of pure carbonate of soda neutralise 94·2 parts of sulphuric acid.

To titrate a soda ash by Descroizilles standard, the method given below must be followed.

1. *Sampling*.—The sample ought to be taken from the centre of the barrel by means of the sampling tool—a sort of cheese taster—because soda which has been in contact with the sides is often a little moist. If the soda has been exposed to moisture the sample must be dried by heating it strongly.

2. *Standard Acid*.—The soda is titrated by a standard acid, which is so adjusted that 92·45 cubic *centimetres* of this dilute acid exactly saturates 10 *grammes* of pure dry carbonate of soda. This standard acid is prepared by diluting 100 *grammes* of concentrated sulphuric acid 66° Baumé with distilled water to 1 *litre*. The liquid must be tested by titrating a chemically pure sample of carbonate of soda made in the laboratory, and which in accordance with what has been said ought to titrate 92·45°. The acid is concentrated or diluted until it gives exactly this result. The standard acid sold by dealers is not always exact.

3. *Mohr's Burette*.—The instrument by which titrations are made is known as Mohr's burette, and consists of a tube capable of holding 100 *centimetres* of standard acid. The tube is graduated and each cubic *centimetre* corresponds to 1° Descroizilles. Ten *grammes* exactly of the sample of soda to be tested is weighed out and placed in a glass beaker or a porcelain basin, and is dissolved in the hot in about 200 cubic *centimetres* of distilled water, to which a few drops of tincture of litmus have been added, and then a drop of normal acid to neutralise the alkalinity of the tincture, so that the liquid has a faint reddish tinge. The operator satisfies himself that he has not added too much acid by spotting a drop on a strip of litmus paper by means of a glass rod dipped in the solution

of the reagent and lye, observing the colouration produced. The spot should become of a feeble reddish colour.

After each operation care is taken to refill the burette exactly to the mark with the standard acid.

Everything being ready, as just said, by opening the pincers the standard acid is allowed to run slowly into the beaker. A brisk effervescence is produced, due to the disengagement of carbonic acid. The liquid is energetically stirred with a glass rod, and when the liquid begins to change to a wine red the standard acid is added cautiously drop by drop, so as not to exceed the saturation point.

A certain quantity of carbonic acid remains in solution, however, and reddens the liquid before the saturation point is actually reached. The beaker is placed over a bunsen burner, and heat applied. After boiling for some time the carbonic acid is expelled, and the blue colour reappears. The beaker is then replaced under the burette, and a few drops of the normal acid run in until the colour becomes red. It is again boiled, and so on until the red colour becomes permanent on boiling. The operator assures himself, as previously indicated, that he has not added an excess of acid.

#### STRENGTH OF ALKALI.

COMPARATIVE TABLE OF DIFFERENT STANDARDS OF STRENGTH.

Descroizilles Degrees $\text{H}_2\text{SO}_4$ .	German Degrees $\text{Na}_2\text{CO}_3$ .	Gay-Lussac Degrees $\text{Na}_2\text{O}$ .	English Degrees $\text{Na}_2\text{O}$ .
0.79	0.85	0.5	0.51
1.58	1.71	1.0	1.01
2.37	2.56	1.5	1.52
3.16	2.42	2.0	2.03
3.95	4.27	2.5	2.54
4.74	5.13	3.0	3.04
5.53	5.98	3.5	3.55
6.32	6.84	4.0	4.05
7.11	7.69	4.5	4.56
7.90	8.55	5.0	5.06

## STRENGTH OF ALKALI—(continued).

Descroizilles Degrees $\text{H}_2\text{SO}_4$ .	German Degrees $\text{Na}_2\text{CO}_3$ .	Gay-Lussac Degrees $\text{Na}_2\text{O}$ .	English Degrees $\text{Na}_2\text{O}$ .
8.69	9.40	5.5	5.57
9.48	10.26	6.0	6.08
10.27	11.11	6.5	6.59
11.06	11.97	7.0	7.09
11.85	12.82	7.5	7.60
12.64	13.68	8.0	8.10
13.43	14.53	8.5	8.61
14.22	15.39	9.0	9.12
15.01	16.24	9.5	9.63
15.81	17.10	10.0	10.13
16.60	17.95	10.5	10.64
17.39	18.81	11.0	11.14
18.18	19.66	11.5	11.65
18.97	20.52	12.0	12.17
19.76	21.37	12.5	12.68
20.55	22.23	13.0	13.17
21.34	23.08	13.5	13.68
22.13	23.94	14.0	14.18
22.92	24.79	14.5	14.69
23.71	25.65	15.0	15.19
24.50	26.50	15.5	15.70
25.29	27.36	16.0	16.21
26.08	28.21	16.5	16.73
26.87	29.07	17.0	17.22
27.66	29.92	17.5	17.73
28.45	30.78	18.0	18.23
29.24	31.63	18.5	18.74
30.03	32.49	19.0	19.25
30.82	33.34	19.5	19.76
31.61	34.20	20.0	20.26
32.40	35.05	20.5	20.77
33.19	35.91	21.0	21.27
33.98	36.76	21.5	21.78
34.77	37.62	22.0	22.29
35.56	38.47	22.5	22.80
36.35	39.33	23.0	23.30
37.14	40.18	23.5	23.81
37.93	41.04	24.0	24.31
38.72	41.89	24.5	24.82
39.51	42.75	25.0	25.33
40.30	43.60	25.5	25.83
41.09	44.46	26.0	26.34
41.88	45.31	26.5	26.85
42.67	46.17	27.0	27.35
43.46	47.02	27.5	27.86
44.25	47.88	28.0	28.36
45.04	48.73	28.5	28.87
45.83	49.59	29.0	29.38
46.62	50.44	29.5	29.89
47.42	51.29	30.0	30.39
48.21	52.14	30.5	30.90
49.00	53.00	31.0	31.41



## STRENGTH OF ALKALI—(continued).

Descroizilles Degrees $\text{H}_2\text{SO}_4$ .	German Degrees $\text{Na}_2\text{CO}_3$ .	Gay-Lussac Degrees $\text{Na}_2\text{O}$ .	English Degrees $\text{Na}_2\text{O}$ .
49'79	53'85	31'5	31'91
50'58	54'71	32'0	32'42
51'37	55'56	32'5	32'92
52'16	56'42	33'0	33'34
52'95	57'27	33'5	33'94
53'74	58'13	34'0	34'44
54'53	58'98	34'5	34'95
55'32	59'84	35'0	35'46
56'11	60'69	35'5	35'96
56'90	61'55	36'0	36'47
57'69	62'40	36'5	36'98
58'48	63'26	37'0	37'48
59'27	64'11	37'5	37'99
60'06	64'97	38'0	38'50
60'85	65'82	38'5	39'00
61'64	66'68	39'0	39'51
62'43	67'53	39'5	40'02
63'22	68'39	40'0	40'52
64'01	69'24	40'5	41'03
64'81	70'10	41'0	41'54
65'60	70'95	41'5	42'04
66'39	71'81	42'0	42'55
67'18	72'66	42'5	43'06
67'97	73'52	43'0	43'57
68'76	74'37	43'5	44'07
69'55	75'23	44'0	44'58
70'34	76'08	44'5	45'08
71'13	76'95	45'0	45'59
71'92	77'80	45'5	46'10
72'71	78'66	46'0	46'60
73'50	79'51	46'5	47'11
74'29	80'37	47'0	47'62
75'08	81'22	47'5	48'12
75'87	82'07	48'0	48'63
76'66	82'93	48'5	49'14
77'45	83'78	49'0	49'64
78'44	84'64	49'5	50'15
79'03	85'48	50'0	50'66
79'82	86'34	50'5	51'16
80'61	87'19	51'0	51'67
81'40	88'05	51'5	52'18
82'19	88'90	52'0	52'68
82'98	89'76	52'5	53'19
83'77	90'61	53'0	53'70
84'56	91'47	53'5	54'20
85'35	92'32	54'0	54'71
86'14	93'18	54'5	55'22
86'93	94'03	55'0	55'72
87'72	94'89	55'5	56'23
88'52	95'74	56'0	56'74
89'31	96'60	56'5	57'24
90'10	97'45	57'0	57'75

## STRENGTH OF ALKALI—(continued).

Descroizilles Degrees H <sub>2</sub> SO <sub>4</sub> .	German Degrees Na <sub>2</sub> CO <sub>3</sub> .	Gay-Lussac Degrees Na <sub>2</sub> O.	English Degrees Na <sub>2</sub> O.
90·89	98·31	57·5	58·26
91·68	99·16	58·0	58·76
92·47	100·02	58·5	59·27
93·26	100·87	59·0	59·77
94·05	101·73	59·5	60·28
94·84	102·58	60·0	60·79
95·63	103·44	60·5	61·30
96·42	104·30	61·0	61·80
97·21	105·15	61·5	62·31
98·00	106·01	62·0	62·82
98·79	106·86	62·5	63·32
99·58	107·72	63·0	63·83
100·37	108·57	63·5	64·33
101·16	109·43	64·0	64·84
101·95	110·28	64·5	65·35
102·74	111·14	65·0	65·85
103·53	111·99	65·5	66·36
104·32	112·85	66·0	66·87
105·11	113·70	66·5	67·37
105·90	114·56	67·0	67·88
106·69	115·41	67·5	68·39
107·48	116·27	68·0	68·89
108·27	117·12	68·5	69·40
109·06	117·98	69·0	69·91
109·85	118·83	69·5	70·41
110·64	119·69	70·0	70·92
111·43	120·53	70·5	71·43
112·23	121·39	71·0	71·93
113·02	122·24	71·5	72·44
113·81	123·10	72·0	72·95
114·60	123·95	72·5	73·45
115·39	124·81	73·0	73·96
116·18	125·66	73·5	74·47
116·95	126·52	74·0	74·97
117·76	127·37	74·5	75·48
118·55	128·23	75·0	75·99
119·34	129·08	75·5	76·49
120·13	129·94	76·0	77·00
120·92	130·79	76·5	77·51
121·71	131·65	77·0	78·01
122·50	132·50	77·5	78·52

He then reads off the tube the number of cubic *centimetres* of test acid used. This figure represents the strength of the soda in Descroizilles degrees. All that has to be done in order to ascertain the Gay-Lussac and the English degree is to consult the table. The Gay-Lussac degree expresses

the percentage strength of the alkali in anhydrous caustic soda,  $\text{Na}_2\text{O}$ , calculated from the atomic weight, 62. The English degree also indicates the percentage strength of the alkali in anhydrous soda,  $\text{Na}_2\text{O}$ , but calculated from the old atomic weight, 64. Newcastle alkali is sold on Gay-Lussac standard—atomic weight, 62; Liverpool alkali on the so-called English standard—atomic weight, 64. For an interesting discussion on the economical influences of this variation in standard of valuation, see *Journal of Society of Chemical Industry*.

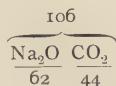
#### *Explanation of the Table.*

The first column gives the Descroizilles degree, that is to say, the number of parts by weight of monohydrated sulphuric acid ( $66^\circ$  Baumé) which are neutralised by 100 parts by weight of the sample. In fact the standard acid is made up in such a manner that each cubic *centimetre* contains  $\frac{1}{10}$  of a *gramme* of sulphuric acid ( $66^\circ$  Baumé), and the sample being tested weighs 10 *grammes* or  $100 \times (\frac{1}{10}$  of a *gramme*). The number of cubic *centimetres* used in neutralising the alkali, therefore, gives in accordance with the definition of the Descroizilles degree the number of parts by weight of sulphuric acid which saturate 100 parts of carbonate of soda. So as not to use up too much test acid, 5 *grammes* are titrated instead of 10, and the number of cubic *centimetres* of test acid used is multiplied by 2.

The second column gives the percentage of carbonate of soda. This percentage equals the Descroizilles degree divided by 92.47 multiplied by 100. In fact 92.47 parts of sulphuric acid saturate 100 parts of pure carbonate of soda. If a sample requires N parts of acid to saturate 100 parts of soda it is evident that the relation or comparative strength of the carbonate of soda in the sample to that of the pure carbonate will be  $\frac{N}{92.47}$ , and to get the percentage the result is multiplied

by 100. The percentage strength is, therefore, equal to the Descroizilles degree  $\times \frac{100}{92.47}$ , or 1.081.

The third column gives the Gay-Lussac degree or the percentage strength in anhydrous soda ( $\text{Na}_2\text{O}$ ). It is calculated from the percentage of carbonate of soda by multiplying that percentage by  $\frac{62}{106}$ , or the Descroizilles degree by  $(\frac{62}{106} \times \frac{1}{92.47} \times 100) = 0.632$ . In fact the elements of carbonate of soda have as equivalents—



from which it follows that the weight of sodium oxide contained in a certain weight of carbonate of soda is equal to the weight of the latter multiplied by  $\frac{62}{106}$ .

*Use of Di-methyl Orange as an Indicator in place of Litmus.*

The use of litmus as a reagent presents this inconvenience, that it is coloured a wine red by carbonic acid. The operation must, therefore, be performed at the boiling temperature. With di-methyl orange the titration may be done in the cold, as that indicator is insensible to carbonic acid. It colours an alkaline solution yellow and an acid one rose red. To seize the exact moment of transition from yellow to rose only a very weak yellow colouration must be given to the alkaline liquid to be tested.

The *Agenda du Chimiste* gives the following instructions regarding this substance: "A test solution of di-methyl aniline orange or Poirier's heliantine is made by dissolving 1 gramme of this substance in a litre of cold water. Mineral acids turn it red, even sulphurous acid; but organic acids, including oxalic acid, produce no change of colour, neither do carbonic acid nor sulphuretted hydrogen. Four drops of this solution are added for every 100 cubic centimetres of liquid to be titrated, which ought to be feebly but decidedly coloured. It must

never be used in hot solutions. It is insensible to carbonic acid, and succeeds in the presence of ammonia, but the quantity of acid necessary to produce the neutral shade of liquid must be deducted."

*Titration of weak Carbonate of Soda Lyes.*—In the titration of weak lyes, that is to say, those marking about 1° to 3° Baumé, it is preferable to use a weaker test acid than the normal alkalimetric test acid (No. 1). This weaker test acid (No. 2) is made by diluting 10 grammes of sulphuric acid 66° Baumé with distilled water to 1 litre. Ten grammes of lye are titrated, the number of cubic centimetres divided by ten gives the Des-croizilles degree of the lye in question. When lyes are being tested it is more convenient to test a given volume of lye than a given weight. Ten cubic centimetres therefore of the lye are taken for titration instead of 10 grammes, and the results expressed by volume and not by weight.

*Solution of certain Problems relating to Caustic and Carbonated Alkali (Soda).*

The author has grouped under the forms of problems the solution of a few questions which may be of interest for the bleacher to solve.

*First Problem.*

Given a solution of carbonate of soda saturated by N cubic centimetres of normal alkalimetric test acid, to find how much carbonate of soda this represents in grammes.

92.45 cubic centimetres of normal alkalimetric test acid saturate 10 grammes of pure carbonate of soda and the following proportion gives the number of grammes X which are saturated by N cubic centimetres of the alkalimetric test acid :

$$\frac{X}{10} = \frac{N}{92.45} \quad X = \frac{10 N}{92.45} = \frac{N}{9.25},$$

i.e., in the quantity of lye tested there are X grammes of carbonate of soda.



*Second Problem.*

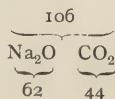
Given a solution of carbonate of soda saturated by  $N$  centimetres of normal alkalimetric test acid, to find how much caustic alkali (anhydrous sodium oxide  $\text{Na}_2\text{O}$ ) this represents in grammes.

92.47 cubic centimetres of test acid saturate 10 grammes of carbonate of soda ( $\text{Na}_2\text{O CO}_2$ ), or 10 grammes  $\times \frac{62}{106}$  of caustic alkali ( $\text{Na}_2\text{O}$ ).  $N$  cubic centimetres of test acid saturate  $X$  grammes of carbonate of soda or  $Y$  grammes of caustic alkali  $\text{Na}_2\text{O}$ , and the value of  $Y$  may be obtained :—

$$Y = X \frac{62}{106} = \frac{N \times 10 \times \frac{62}{106}}{92.45} = \frac{N}{10} \times 0.632.$$

*Remark I.*—Observe that  $N \times 0.632^\circ$  represents the Gay-Lussac degree and the Newcastle degree, and is found in the table.

*Remark II.*—The equivalents in weights of the elements of carbonate of soda are :—



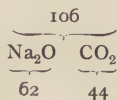
The weight  $Z$  of sodium oxide ( $\text{Na}_2\text{O}$ ) contained in any given weight ( $P$ ) of carbonate of soda may be found by the following proportion :—

$$\frac{Z}{62} = \frac{P}{106} \quad Z = P \times \frac{62}{106} = P \times 0.585.$$

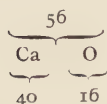
*Third Problem.*

What weight  $X$  of quicklime is required to transform a given weight of carbonate of soda  $P$  from carbonate of soda into carbonate of lime, with liberation of free caustic soda ?

The equivalent of carbonate of soda being



that of quicklime being



To transform 106 parts of carbonate of soda requires 56 parts of quicklime, and to transform a weight P of carbonate of soda a quantity of lime X will be required, as shown in the following proportion :—

$$\frac{X}{P} = \frac{56}{106} \quad X = P \times \frac{56}{106} = P \times 0.53.$$

In practice, to make allowance for impurities in the lime two-thirds of the weight of the carbonate of soda are used.

#### *Fourth Problem.*

It is desired to make an alkaline lye so that the alkali may be present therein as a mixture of 80 per cent. of carbonate of soda and 20 per cent. of caustic soda ( $\text{Na}_2\text{O}$ ) ; what are the quantities of carbonate of soda and lime to employ ?

Let P be the total weight of caustic and carbonated alkali desired to be obtained :—

$$P = 0.80 P \text{ Na}_2\text{OCO}_2 + 0.20 P \text{ Na}_2\text{O}.$$

1. 80 per cent. of P must be carbonate.

2. 62  $\text{Na}_2\text{O}$  corresponding to 106  $\text{Na}_2\text{CO}_3$  0.20 P = X.

Whence the proportion

$$\frac{62}{0.20 P} = \frac{106}{X} \quad X = 0.20 P \times \frac{106}{62}$$

$$X = 0.20 P \times 1.71.$$

X therefore represents the weight of carbonate of soda, which contains 0.20 P of caustic alkali  $\text{Na}_2\text{O}$ .

To know the weight of lime required to transform the weight X of carbonate of soda into caustic soda, by referring to problem three it will be seen that this weight is

$$Y = 0.53 X \text{ or } Y = 0.20 P \times 1.716 \times 0.53.$$

#### *Fifth Problem.*

It is required to make a lye the alkali of which is to be in

the proportion of 80 per cent. of carbonate to 20 per cent. of caustic. The caustic soda to be used is liquid. It is required to know how much carbonate of soda and how many *litres* of caustic soda must be used.

Let P be the total weight of caustic and carbonated alkali to be contained in the desired mixture :—

1. The weight of the carbonate of soda will be  $0.80 P$ .

2. To ascertain how many *litres* of caustic soda are required, the weight of soda in the *litre* of liquid must be determined. This is done by titration, and the result calculated to the *litre*. Let M be this weight and Z the number of *litres* sought. We then have

$$Z \times M = 0.20P \quad Z = \frac{0.20P}{M}$$

### *Solvay Soda Ash.*

The best carbonate of soda to use for bleaching is Solvay soda ash. This product is very pure, as will be seen from the following analysis :—

#### ANALYSIS OF SOLVAY SODA ASH.

	PER CENT.
Water - - - - -	0.310
Silica and carbon - - - - -	0.023
Sodium chloride - - - - -	0.320
Ferric oxide ( $\text{Fe}_2\text{O}_3$ ) - - - - -	0.006
Alumina ( $\text{Al}_2\text{O}_3$ ) - - - - -	0.030
Carbonate of lime - - - - -	0.035
Carbonate of magnesia - - - - -	0.037
Carbonate of soda - - - - -	99.239
	<hr/> 100.000 <hr/>

This substance bleaches much less energetically than caustic soda, but its use is attended with less danger in the bleaching of fabrics which are liable to be easily weakened or attenuated. It is also to be preferred for use with those pieces, portions of which are woven with coloured yarn, because soda attacks the colour, rendering it more or less pale.

The following table gives the relationship between degrees Baumé and the number of *grammes per litre* :—

Degrees Baumé.	Weight in <i>grammes per litre</i> or <i>kilogrammes per cubic</i> <i>metre</i> or <i>lb. per 100 gals.</i>
12	100
6.5	50
3.9	30
3.5	26
3	23
2.5	20
2	16
1.8	15
1.5	12.5
1.2	10
1	8
0.7	6
0.6	5

#### *Caustic Soda.*

This is the trade name for sodium hydrate  $\text{Na}_2\text{O}$ ,  $\text{H}_2\text{O}$  ( $\text{NaHO}$ ). The caustic soda is used for lyes by itself, or mixed with carbonate of soda, and then this mixture is termed salt of soda (*sel de soude*).

Caustic soda being much more energetic in its action than carbonate of soda or salt of soda certain precautions must be taken in its use ; amongst others, it must not be allowed to act on the fabrics in contact with the air, or the fabrics will be completely burnt in those parts. This was found to be the result of observations made by M. Koechlin in Alsace—observations the correctness of which has been verified by the author.

Caustic soda is advantageously used in Mather and Platt's keir, but it may be used in all kinds of keirs provided care and attention be taken to wash the fabrics thoroughly before sending them to the bleaching green.

Caustic soda is met with in commerce in the solid state ; it is sent out in wrought-iron cylinders. As it is very hard,

it is broken with a sledge-hammer. The workmen should use spectacles to protect the eyes from its corrosive action.<sup>1</sup>

The soda is dissolved in the proportion of 333 to 335 grammes per litre of water (say 3 lb. to the gallon) and a lye is obtained marking 33° to 35° Baumé at 15° C. This solution is boiled for about an hour, during which time a great deal of impurity floats to the top in the form of scum, which is removed by a wooden rake. This concentrated lye is used in the preparation of lyes for bucking or lye-boiling by the addition thereto of the necessary quantity of water to reduce it to the desired strength. The strength of these lyes varies from 0.5° to 2° and even 3° Baumé.

Caustic soda strongly attacks iron and copper when concentrated. For making a solution of 33° Baumé it is best to use a cast-iron tank, with cast-iron stop-cocks. Cast iron resists alkali far better than copper, and, moreover, is much cheaper.

Caustic soda 110° Descroizilles has the following composition :—

## ANALYSIS OF COMMERCIAL CAUSTIC SODA 110° DESCROIZILLES.

	PER CENT.
Sodic hydrate ( $\text{NaHO}$ ) - - - - -	89.600
Sodic carbonate ( $\text{Na}_2\text{CO}_3$ ) - - - - -	2.481
Sodic chloride ( $\text{NaCl}$ ) - - - - -	3.919
Sodic sulphate ( $\text{Na}_2\text{SO}_4$ ) - - - - -	3.419
Sodic sulphide ( $\text{Na}_2\text{S}$ ) - - - - -	0.025
Sodic silicate ( $\text{Na}_2\text{OSiO}_3$ ) - - - - -	0.304
	<hr/> 99.748

These proportions correspond to :—

	PER CENT.
Sodic anhydride ( $\text{Na}_2\text{O}$ ) - - - - -	69
Combined water - - - - -	20
Impurities - - - - -	11
	<hr/> 100

<sup>1</sup> Caustic soda in coarse powder is now an article of commerce. It is much to be preferred to the solid, the breaking up of which is dangerous. Remedy for caustic soda in eye : bathe the eye with vinegar or highly dilute acetic acid.  
—Tr.



*Remark.*—It is very necessary to realise the exact meaning of the terms used to denote the strength of an alkali or an alkaline liquid, whether in degrees Descroizilles or otherwise, and to be able to convert these terms into the actual percentage of soda. In a case like the present this may be done in the following way : 92.45 cubic *centimetres* of normal alkalimetric test acid saturates 10 *grammes* of carbonate of soda ( $\text{Na}_2\text{CO}_3$ ) or 10 *grammes*  $\times \frac{6.2}{106}$  of anhydrous soda, and the following proportion gives the number Y of cubic *centimetres* of the standard acid required to saturate 10 *grammes* of soda :—

$$\frac{Y}{92.47} = \frac{10}{10 \times \frac{6.2}{106}} \quad Y = 92.47 \times \frac{106}{6.2} = 158.06;$$

that is to say, if the caustic soda was pure and anhydrous its alkalimetric degree would be 158.06. Now its alkalimetric degree is 110, the proportion of carbonate of soda is therefore  $\frac{110}{158.06} = 0.69$ , as indicated previously.

*Titration of Caustic Soda.*—Caustic soda is titrated in the same way as carbonate of soda. Five or 10 *grammes* of the soda to be tested are taken and, using litmus as indicator, the number of half cubic *centimetres* or cubic *centimetres* of the standard acid required to saturate this quantity of soda are determined. These represent respectively the degree Descroizilles according as to whether 5 or 10 *grammes* of caustic were taken. If the sample to be tested is entirely caustic, there is no necessity to heat, since there is no disengagement of carbonic acid to redden the litmus. Di-methyl orange may also be used as indicator.

*Titration of a Mixture of Carbonated and Caustic Alkali.*—Very often the alkali to be tested does not consist solely of caustic soda or carbonate of soda, but is a mixture of both. It is useful to know the proportions in which the carbonate of soda and the caustic soda are mixed. This is determined in the following way :—

*Total Alkali.*—The total alkali is determined by the method

previously indicated, using litmus or di-methyl orange as indicator.

*Caustic Alkali.*—Poirier's blue, C.L.B., is employed as indicator in the titration of the caustic alkali, in virtue of the following properties. In presence of free alkalies it is red, and blue with alkaline carbonates and salts of weak acids. The number of cubic *centimetres* of standard acid required to convert the red alkaline solution to blue is determined. This figure gives the alkalinity due to caustic soda. As, on the other hand, the total alkali has been determined, the alkalinity due to carbonate of soda is found by difference.

*Mixtures of Carbonated and Caustic Alkali.*—The alkaline bodies sold in commerce under different names are mixtures of carbonated and caustic alkali, with a considerable amount of water and impurities. These products are sold according to their degree Descroizilles, with an indication of the amount of caustic present. Here is an example of this kind titrating 80° Descroizilles :—

	PER CENT.	
Soda - - - - -	15'5	} Na HO
Combined water - - - - -	4'5	
Carbonate of soda - - - - -	59'0	
Impurities - - - - -	21	
	<hr/> 100'0 <hr/>	

*Note on a Process for Manufacturing Caustic Soda.*

In certain cases it might be advantageous to prepare in the works itself the caustic soda required, by the decomposition of carbonate of soda by lime. The following are the advantages and the disadvantages of this method of procedure.

Solvay soda ash contains :—<sup>1</sup>

	PER CENT.
Anhydrous soda - - - - -	58
Carbonic acid - - - - -	41
Impurities - - - - -	1
	<hr/> 100 <hr/>

<sup>1</sup> See p. 179.

Solid caustic soda 110° Descroizilles contains :

	PER CENT.
Anhydrous soda ( $\text{Na}_2\text{O}$ ) - - - - -	69'00
Combined water - - - - -	20'00
Impurities - - - - -	11'00
	<hr/>
	100'00
	<hr/>

Solvay soda ash<sup>1</sup> costs about 16 francs the 100 *kilogrammes* and caustic soda 110° Descroizilles 33 francs the 100 *kilogrammes*. It follows that the soda of the carbonate is paid for at the rate of

$$16 \text{ fr.} \times \frac{100}{58} = 27.60 \text{ francs the } 100 \text{ kilogrammes,}$$

and that the soda of the caustic soda 110° Descroizilles is paid for at the rate of

$$33 \text{ fr.} \times \frac{100}{69} = 49 \text{ francs the } 100 \text{ kilogrammes,}$$

which leaves a margin of 49 fr. - 28 fr. = 21 francs per 100 *kilogrammes*. If there be added to the 28 francs the cost of 110 *kilogrammes* of lime necessary to render the soda caustic the margin will then be 49 fr. - (28 fr. + 3 fr.) = 18 francs. It may here be remarked that the expense of labour and steam in caustifying the carbonate of soda is almost the same as that required to dissolve the caustic soda.

The process of decarbonatation is very simple and the material costs but little. A certain quantity of soda ash is dissolved, then the corresponding quantity of quicklime is added, and the whole is kept boiling, by a steam pipe, for about two hours. A sample of the liquid is filtered, and if a dilute acid produces no effervescence the caustification is complete; if, on the contrary, the liquid becomes cloudy on the addition of carbonate of soda there is an excess of lime. It is better to always maintain a slight excess of carbonate, which cannot be in any way injurious.

The whole is allowed to stand, and the lime, now in the carbonated condition, falls to the bottom. The clear liquid is

<sup>1</sup> See p. 179.

decanted and used in the preparation of lyes, the precipitated carbonate of lime is washed, allowed to settle, and the clear liquid again decanted, and this operation is repeated until the precipitate is exhausted of soda. The precipitate when sufficiently washed is thrown on the rubbish heap.

Problem No. 3 shows, theoretically, that the lime ought to be  $\frac{5.3}{100}$  of the carbonate, but in order to allow for impurities two-thirds of the weight of the carbonate of soda should be used.

This method of caustifying soda is recommended by the manual of bleaching published in Ireland under the title of *Hints to Bleachers*.

By the same process carbonate of soda lyes may be prepared containing a certain percentage of caustic soda ( $\text{Na}_2\text{O}$ ). The proportions in which it is necessary to mix the carbonate of soda and the lime are indicated in problem No. 4; a little more quicklime being used so as to make allowance for impurities.

The Irish manual recommends the use of a lye made by adding one-sixth of the weight of the lime to the carbonate. A lye is thus obtained 80 per cent. of carbonated and 20 per cent. of caustic alkali. It is necessary to allow the precipitated carbonate of lime time to settle, even although it has no injurious action on the fabrics.

Carbonate of soda may be replaced by sulphate of soda. The soda is liberated by the lime which is transformed into sulphate of lime. The advantage of this substitution lies in the low price of sulphate of soda. On the other hand, the precipitated sulphate of lime deposits badly; numerous washings must be resorted to. Moreover, the soda obtained is not so pure in consequence of the impurities present in low-priced sulphate of soda.

*Method of Preparing Caustic Soda by successively Enriching the Wash Liquors.*

The method of exhausting the carbonate of lime muds by successive washings has the disadvantage of yielding lyes the

strength of which progressively diminishes, and requiring reservoirs of vast storage capacity to hold them. In order to obtain concentrated lyes of uniform strength the following method may be pursued :—

Suppose five tanks are at our disposal : 1, 2, 3, 4, 5.

*First Day.*—Charge 1 with lime and soda ash, fill with water, agitate energetically, and let stand till morning.

*Second Day (Morning).*—Charge 2 with lime and soda ash. Syphon the clear liquid from 1 into 2. Fill 1 with water (first washing). Stir 1 and 2 energetically, and allow to stand.

*Second Day (Evening).*—Charge 3 with lime and soda ash.

Pass the clear liquid from 2 into 3.

„ „ 1 „ 2.

Fill 1 with water (second washing). Stir 1, 2 and 3 energetically, and allow to stand.

*Third Day (Morning).*—Charge 4 with lime and soda ash.

Pass the clear liquid from 3 into 4.

„ „ 2 „ 3.

„ „ 1 „ 2.

Fill 1 with water (third washing). Stir 1, 2, 3 and 4 energetically, and allow to stand.

*Third Day (Evening).*—Charge 5 with lime and soda ash.

Pass the clear liquid from 4 into 5.

„ „ 3 „ 4.

„ „ 2 „ 3.

„ „ 1 „ 2.

Fill 1 with water (fourth washing). Stir 1, 2, 3, 4 and 5 energetically, and allow to stand.

*Fourth Day (Morning).*—Syphon off the clear liquid from 5, which is a concentrated solution of caustic soda, and store it in reserve.



Pass the clear liquid from 4 into 5.

„	„	3	„	4.
„	„	2	„	3.
„	„	1	„	2.

Stir 2, 3, 4 and 5 energetically, and allow to stand. The mud of 1 having been washed four times are thrown on the rubbish heap.

*Fourth Day (Evening).*—Charge 1 with lime and soda ash.

Pass the clear liquid from 5 into 1.

„	„	4	„	5.
„	„	3	„	4.
„	„	2	„	3.

Fill 2 with water, stir all the tanks, and allow to stand.

*Fifth Day (Morning).*—Syphon the clear liquid from 1 and store the concentrated caustic lye in reserve.

Pass the clear liquid from 5 into 1.

„	„	4	„	5.
„	„	3	„	4.
„	„	2	„	3.

Stir 3, 4, 5 and 1, and allow to stand. Transfer mud of 2 to rubbish heap as sufficiently exhausted.

*Fifth Day (Evening).*—Charge 2 with lime and soda ash.

Pass the clear liquid from 1 into 2.

„	„	5	„	1.
„	„	4	„	5.
„	„	3	„	4.

Fill 3 with water, stir all the tanks, and allow to stand.

*Sixth Day (Morning).*—Syphon the concentrated soda lye from 2, and continue the operations as on the preceding days.

*Remark I.*—Sixty kilogrammes of carbonate of soda and 40 kilogrammes of quicklime to 1,000 litres of water are good pro-

portions. Say 60 lb. and 40 lb. respectively to the 100 gallons. If the lime is slaked, 50 *kilogrammes* must be used.

*Remark II.*—The charge of lime and soda ash may be made as follows: a lime paste is made with a very small quantity of liquid, and beaten up in such a manner as to crush all the lumps. Then the reagent tank is filled with the liquid in the preceding tank, and the soda ash is dissolved by passing it through a sieve so as to crush all the lumps.

*Remark III.*—Mixing is done by hand with a shovel, or, better still, by mechanical agitators fixed to each tank. If heat be used, the open steam, as it issues from the coil in the bottom of each pan, agitates the liquid to such an extent as to sufficiently mix the contents of the tank.

*Remark IV.*—The liquids are transferred from one tank to another by a pump, the suction and discharge tubes of which are made of india-rubber, so that they can be adapted in succession to each series of two tanks.

*Determination of the Useful Duration of the Strength of Lyes.—  
Revivifying Lyes.*

In order to determine how the operation is going on in lye-boiling, samples of the lye are taken from the keir from hour to hour, and the amount of soda absorbed in the interval by the fabrics is ascertained. It is found that after a certain time the strength of the lye does not diminish any further. When this happens, it is of no use to continue boiling any further. The lyes used in the first lye-boils are generally exhausted at the end of seven or eight hours' boiling, after which nothing remains but to run them off. But when the fabrics are nearly bleached they absorb but very little soda, in which case there is good reason for not running the lyes away. They should be stored for the boiling of fabrics in a less advanced stage of the bleaching process after they have been revived by an

addition of soda sufficient to replace that which was absorbed in the previous operation.

The experiments are made on 10 cubic *centimetres* of lye, and with deci-normal standard acid (*i.e.*, normal acid diluted with ten times its volume of water).

As the lye has become of a brown colour, coloured indicators are of no use in deciding the point of neutralisation. A strip of litmus paper is used instead. It is dipped from time to time into the liquid as the standard acid is being run in. The moment when the litmus paper passes from blue to red may thus be easily determined. If the lye contains carbonate, the carbonic acid remaining in solution must be expelled by boiling, otherwise it would turn the litmus paper red before the saturation point was reached.

## CHAPTER XIV.

### CHLOROMETRY, OR TITRATION OF DECOLOURISING CHLORIDES.

*Chlorometric Degree—Titration by Arsenious Acid—Preparation of the Standard Arsenious or Chlorometric Solution—Method of Titration—Titration of Chloride of Lime in Powder—Titration of Liquid Chloride of Lime—Titration of Chlorozone—Titration of Chemick—Wagner's Chlorometric Method—Preparation of Standard Solutions—Titration of a Chemick—Apparatus for Chlorine Valuation—Alkali in Excess in Decolourising Chlorides.*

*Chlorometric Degree.*—The chlorometric degree of chloride of lime varies between 100 and 110 degrees. That means that 1 kilogramme of chloride of lime can decolourise or bleach to the same extent as 100 to 110 litres of dry gaseous chlorine reduced to 0° C., and measured at the atmospheric pressure.

As far as liquid chlorides are concerned, the chlorometric degree is an index of the number of litres of active chlorine contained in a litre of liquid chloride. As an example, when it is said that Brochoki's chlorozone tests 35 chlorometric degrees, that signifies that a litre of chlorozone contains 35° of active or available chlorine. When any one speaks of a chemick of 1 or 2 chlorometric degrees, what is meant is that that chemick contains 1 or 2 litres of active chlorine per litre.

In France the chlorometric degree of *solid* chlorides refers

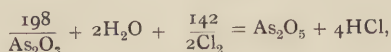
to the *weight*, and the chlorometric strength of *liquid* chlorides refers to the *volume*.

The English or German degree indicates the weight of active chlorine contained in the chloride. Therefore, N English or German degrees = M French degrees  $\times 3.17$  grammes, 3.17 grammes being the weight of a *litre* of chlorine at  $0^{\circ}$  C. at the normal pressure.

*N.B.*—Chlorine exists in two different states in bleaching chlorides. One part of the chlorine exists in such a state of combination that it plays the same part, as far as its decolourising properties are concerned, as gaseous chlorine dissolved in water. This is active chlorine. Another portion of the chlorine is combined in such a manner as to be useless for bleaching purposes. This is inert chlorine. Thus in liquid chloride of soda there is present hypochlorite of soda, the chlorine of which possesses decolourising properties, and chloride of sodium or sea salt, the chlorine of which has no action. Volumetric or titration methods only give the available chlorine. These methods are based on the oxidising strength of the chlorine, and the results obtained show that the samples in question have the same oxidising value or the same decolourising properties as a certain number of *litres* of chlorine. But it is quite possible that it is not the chlorine alone which produces this oxidation of the oxygenated bodies; the oxygen of the hypochlorite may also oxidise directly, and this is the reason why it is *not* said that a chloride of any given chlorometric degree contains so many *litres* of active chlorine, but only that its decolourising or bleaching properties have the same effect as so many *litres* of active chlorine.

#### *Titration by Arsenious Acid.*

This method, due to Gay-Lussac, is based on the following reaction :—





that is to say that two equivalents of chlorine transform one equivalent of arsenious acid into arsenic acid. Now a *litre* of chlorine weighs 3.17 grammes. If, therefore, it be desired to ascertain the weight of arsenious acid which will be converted into arsenic acid by 3.17 grammes of chlorine, the necessary data is afforded by the following proportion sum :—

$$\frac{3.17 \text{ gr.}}{142 (2\text{Cl})} = \frac{X}{198 (\text{As}_2\text{O}_3)} = \frac{3.17 \times 198}{142} = 4.42 \text{ As}_2\text{O}_3.$$

That is to say that to convert 4.42 of arsenious acid into arsenic acid it requires 3.17 grammes or, in other words, 1 *litre* weight of chlorine.

*Preparation of the Standard Arsenious or Chlorometric Solution.*

Vitreous arsenious acid ought to be pulverised whilst warm, and cooled out of contact with a moist atmosphere ; 4.12 grammes of arsenious acid are weighed, then dissolved in a solution containing 150 cubic *centimetres* of hydrochloric acid and 150 cubic *centimetres* of distilled water, and the whole heated for four or five hours to 40° C. on the water bath. After solution and cooling, make up to a *litre* with distilled water.

This solution is then standardised in such a manner that to transform 1 cubic *centimetre* of arsenious into arsenic acid it requires 1 cubic *centimetre* of chlorine.

*Saturation point.*—To know at what moment all the arsenious acid is converted into arsenic acid, 10 cubic *centimetres* are drawn off and a few drops of sulphindigotic acid are added thereto ; the chlorine first of all transforms the arsenious acid into arsenic acid, then a drop in excess decolourises the sulphindigotic acid. This shows that the reaction is complete.

*Method of Titration.*

Ten cubic *centimetres* of the arsenious acid solution are run into a test glass and tinted blue with sulphate of indigo,

and the chlorinated liquid is added from a burette until complete decolouration is effected and the solution so adjusted that 10 cubic *centimetres* of the arsenious acid solution equals 10 cubic *centimetres* of available or active chlorine.

Supposing then, for example, that 6 cubic *centimetres* of the liquid chloride are required to give the chlorometric degree, the following proportion sum results :—

$$\frac{X}{10 \text{ cc. chlorine}} = \frac{1 \text{ litre}}{6 \text{ cc. chlorinated liquid}}$$

$$X = \frac{10}{6} = 1.66 \text{ chlorometric degrees ;}$$

or, in other words, there is 1 *litre* 66 cubic *centimetres* of chlorine per *litre* in the chlorinated solution tested.

If a burette be divided into cubic *centimetres* and tenths of cubic *centimetres*, it is necessary each time to calculate this proportion sum. But in the special chlorometric burettes this proportion sum is calculated beforehand, in fact the chlorometric strength is indicated on each division of the burette.

In a case where it is desired to make use of a burette graduated in cubic *centimetres*, the following table will give the chlorometric strength corresponding to the number of cubic *centimetres* run in.

*N.B.*—The addition of hydrochloric acid to the solution of arsenious acid is absolutely necessary to liberate the chlorine from its state of combination, otherwise only one portion of the chlorine would come into play.

The volume of arsenious acid is taken as the constant volume and not that of the chemick to be tested, because the hydrochloric acid contained in the arsenious acid might disengage more chlorine than the arsenious would absorb and the gaseous chlorine liberated would escape titration.

COLUMN A.—NUMBER OF CUBIC CENTIMETRES OF NORMAL CHLOROMETRIC SOLUTION RUN INTO 10 C.C. OF THE CHEMICK TO BE TESTED.

COLUMN B.—CORRESPONDING CHLOROMETRIC DEGREE.

A	B	A	B	A	B
1	10	8.5	1.17	31	0.32
1.2	8.3	9	1.11	32	0.31
1.4	7.1	9.5	1.05	33	0.30
1.6	6.6	10	1	34	0.29
1.8	5.5	11	0.91	35	0.28
2	5	12	0.83	36	0.27
2.2	4.5	13	0.77	37	0.27
2.4	4.2	14	0.71	38	0.26
2.6	3.8	15	0.66	39	0.25
2.8	3.5	16	0.62	40	0.25
3	3.3	17	0.58	42	0.24
3.2	3.1	18	0.55	44	0.23
3.4	2.9	19	0.52	46	0.22
3.6	2.7	20	0.50	48	0.21
3.8	2.6	21	0.48	50	0.20
4	2.5	22	0.45	55	0.18
4.5	2.2	23	0.43	60	0.17
5	2	24	0.42	65	0.15
5.5	1.82	25	0.40	70	0.14
6	1.66	26	0.38	75	0.13
6.5	1.53	27	0.37	80	0.12
7	1.43	28	0.35	90	0.11
7.5	1.33	29	0.34	100	0.10
8	1.25	30	0.33		

The chlorometric burette is convenient for the titration of chlorinated liquids the strength of which varies between 2.0 and 0.4 chlorometric degrees. If a stronger liquid is being dealt with, there will be much less of the standard solution to be run in, and a small error in reading will cause a considerable error in the valuation of the chlorometric strength. If the chlorinated liquid tests below 0.4 chlorometric degree, a large volume of the standard solution must be run in; this, besides being troublesome, will dilute the arsenious solution so much that it will be difficult to catch the commencement of the bleaching of the indigo. In the first case it is advisable to dilute with water, in a known proportion, the chlorinated liquid

so as to bring it between 1 and 2 chlorometric degrees. The test is made and the result is multiplied by the rate of dilution. In the second instance easier results may be obtained by R. Wagner's method for titration of weak chemicks detailed further on.

*N.B.*—The sulphate of indigo is not completely decolourised by chlorine; it first assumes a greenish tint with violet reflections, and then becomes yellow, and it is the transitional state from green to yellow which indicates the point at which to stop. This stopping-point requires an experienced eye to catch it, and with gas-light it is still more difficult.

In commercial analyses sulphindigotic acid has been displaced by Poirier's orange. A few drops of Poirier's orange colour the 10 cubic *centimetres* of standard arsenious acid a rose colour, and as soon as the chlorinated liquid has oxidised the arsenious acid into arsenic acid it decolourises a further drop of Poirier's orange. The reaction is very distinct even in gas-light.

*Titration of Chloride of Lime in Powder.*

Chloride of lime in powder generally tests between 90 and 120 chlorometric degrees.

Ten *grammes* of the chloride of lime to be tested are weighed into a mortar, a little water added, and the whole beaten with a pestle so that no lumps remain; then this paste is made up with water to 1 *litre*. The whole is well mixed and allowed to stand until a clear liquid is obtained. The chlorometric burette is filled to 0° with this liquid. Ten cubic *centimetres* of the standard arsenious acid are run into a beaker and coloured by one or two drops of sulphate of indigo; then the chlorinated liquid is run in from the burette, drop by drop, stirring with a glass rod. The reaction is finished when the bluish green colour of the indigo has disappeared. The reading of the burette gives the chlorometric degree,

whether it be read directly from the burette or found by means of a table.

If the chloride of lime tested 120 chlorometric degrees, for example, there will be used up in the test just described 120 chlorometric degrees; that is to say, in the 10 *grammes* of chloride tested there would be 1.2 *litre* of chlorine, and in a *kilogramme*, or 1,000 *grammes*, there is a 100 times more, or 120 *litres* of chlorine. The chlorometric degree is therefore 120.

#### *Titration of Liquid Chloride of Lime.*

When chloride of lime is beaten up with water there is obtained a liquid chloride of lime which tests generally 7 to 10 chlorometric degrees. In making the test direct only 1 or 2 cubic *centimetres* would be required to be run in, hence a small error in the reading would lead to a considerable error in the estimated strength. It is advisable, therefore, to take 100 cubic *centimetres* of the liquid chloride to be tested, and to dilute with water to form a *litre*, and to make the test on this dilute solution. The result is multiplied by 10 to obtain the chlorometric strength of the original chloride.

The chloride of soda made in bleach works, of 7 to 10 chlorometric degrees, may be tested in the same manner.

#### *Titration of Brochoki's Chlorozone (35 chlorometric degrees).*

Fifty cubic *centimetres* of the chlorozone are diluted with water to 1 *litre*, the test is made on this diluted solution, and the result multiplied by 20 to obtain the chlorometric degree of the chlorozone.

#### *Valuation of the Strength of the Chemicks used in Bleaching.*

In bleach works where the chemicks are not heated the strength of the chemicks varies between 0.40 and 3 chlorometric degrees. The chlorometric burette is therefore filled directly with the liquid to be tested, the test performed as

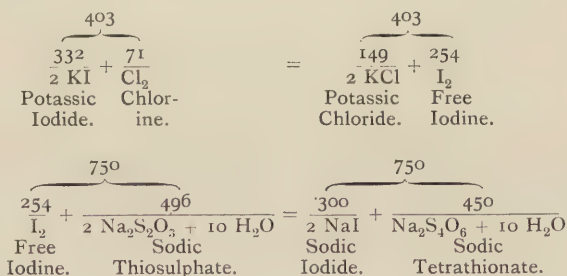


indicated, and the reading of the burette or the table will give the chlorometric strength. When the chemicks are heated they are used more dilute, say 0.15 to 0.70 chlorometric degree. To ascertain their strength it is advisable to use Wagner's method, by which the  $\frac{1}{100}$  part of a chlorometric degree may be estimated.

*Wagner's Chlorometric Method.*

The chlorometric method of Wagner is based on the decomposition of the iodide of potassium by chlorine in a hydrochloric acid solution. The iodine is liberated in proportional weight to that of the chlorine. The liberated iodine is estimated by hyposulphite of soda, which dissolves it as colourless iodide of sodium, with formation of a tetrathionate or salt of the thionic series. The iodine liberated by the chlorine communicates a yellow colour to the liquid, and the hyposulphite of soda, by converting the iodine into iodide of potassium, causes this coloration to completely disappear. It is very easy to catch the point at which the reaction is complete.

The reactions take place according to the following equations:—



It follows from these equations that one equivalent of chlorine (35.5) liberates one equivalent of iodine (127), and that this equivalent of iodine is converted into iodide of potassium by one equivalent of hyposulphite of soda (248).

The quantity of hyposulphite of soda, X, corresponding to 1 *litre* of chlorine is arrived at as follows :—

$$\frac{X}{248} = \frac{3.17}{35.5} X = 22.1 \text{ grammes.}$$

*Preparation of Standard Solutions.*

*Hyposulphite of Soda.*

22.1 grammes of hyposulphite of soda are dissolved in distilled water and made up to a *litre*. Each cubic *centimetre* of this solution is equivalent to 1 cubic *centimetre* of gaseous chlorine.

*Potassium Iodide.*

The potassium iodide is dissolved in an unknown quantity of water. A good proportion is to dissolve 100 grammes of potassium iodide in a half *litre* flask, and to preserve this solution in a blue or yellow bottle, because light decomposes iodide of potassium. One cubic *centimetre* of this solution contains a little more iodine than 10 cubic *centimetres* of chlorine can liberate.

The following proportion gives the weight X of iodide of potassium, the iodine of which is liberated by 3.17 grammes of chlorine, or 1 *litre* :—

$$\frac{X}{166 \text{ (KI)}} = \frac{3.17 \text{ grammes}}{35.5 \text{ Cl}} X = 14.8 \text{ grammes.}$$

It follows, therefore, that 1 cubic *centimetre* of a solution of iodide of potassium made in the proportion of 148 grammes per *litre* contains the quantity of iodine that can be liberated by 10 cubic *centimetres* of gaseous chlorine.

*Hydrochloric Acid.*

The chemick to be tested is acidulated with hydrochloric acid. The pure strong acid should not be used, as the action would be too violent and the iodine would be precipitated in crystals. One part of hydrochloric acid, 22° Baumé, is diluted with 3 parts of water.

*Titration of a Chemick.*

Ten cubic *centimetres* of the chemick to be tested are run into a glass, then the iodide of potassium is added, and two drops of hydrochloric acid added to liberate the chlorine. The chemick then takes a yellow tint. A burette divided into cubic *centimetres* and tenths of cubic *centimetres* is then filled to 0° with the hyposulphite of soda, which is then run in until the brown colouration completely disappears.

The number of tenths of cubic *centimetres* used indicates the hundredths of the chlorometric degree. For instance, if 35 tenths of a cubic *centimetre*, or 35 small divisions be used, that indicates that the chemick is 0.35° chlorometric.

*N.B.*—I. Generally a 10 cubic *centimetre* burette is used for running in the hyposulphite of soda. So as to avoid having to fill it several times, the liquid to be titrated should be diluted so as not to exceed 1° chlorometric. In general, chemicks for textile fabrics do not exceed this strength, and are titrated directly.

If the bath be of 2° to 3° chlorometric, as is the case for yarn, it is diluted with water to double or triple its volume, and the result found by titration multiplied by 2 or 3, as the case may be.

In the case of solutions of chloride of lime testing 8° to 10° chlorometric, 100 cubic *centimetres* are drawn off and diluted to 1 *litre*, titrated, and the result multiplied by 10.

Brochoki's chlorozone tests 35° chlorometric. Ten cubic *centimetres* are taken and diluted with water to 1 *litre*, the solution titrated, and the result multiplied by 100.

II. It is necessary to run in enough iodide of potassium to liberate all the chlorine in the chemick to be tested. A cubic *centimetre* of iodide of potassium prepared as above is added for every chlorometric degree, but it is always better to add too much than too little. In the latter case the titration will give erroneous results, as there will not be enough iodine to liberate all the chlorine.

III. It is sufficient to run in two or three drops of hydrochloric acid to disengage the chlorine. Pure (concentrated) hydrochloric acid should not be used, because the chlorine is disengaged too quickly, does not remain in solution in the liquid, and precipitates the iodine in black crystals. Moreover, hyposulphite of soda dissolves this iodine with greater difficulty, and thereby renders the titration liable to errors. This also occurs when a too highly concentrated bath is titrated. It is better to recommence the experiment by adding water to the vessel after running in the 10 cubic *centimetres* of the liquid to be titrated.

*Apparatus used in Chlorometry.*

By whatever method the chlorometric strength is determined the apparatus used should comprise the following:—

1. A mortar and pestle to crush the chloride of lime to be tested.
2. *Litre* flask with mark.
3. A cylindrical glass jar of 500 cubic *centimetres* or 1,000 cubic *centimetres* divided into *decilitres* and *centilitres*.
4. Several test glasses and stirring rods.
5. One 100 cubic *centimetre* pipette, one 10 cubic *centimetre* pipette without divisions, and another 10 cubic *centimetre* pipette divided into cubic *centimetres*.
6. One 10 cubic *centimetre* burette divided into cubic *centimetres* and tenths of cubic *centimetres*. Another burette of 25 cubic *centimetres* divided into cubic *centimetres* and tenths of cubic *centimetres*.
7. A *litre* of standard arsenious acid or normal chlorometric solution.
8. A bottle of sulphindigotic acid.
9. A *litre* of hyposulphite of soda, 22.1 grammes per *litre*.
10. Half *litre* of a solution of iodide of potassium—200

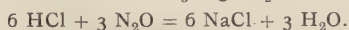
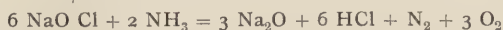
grammes to the *litre*—which is kept in a yellow or blue glass bottle.

11. A bottle of dilute hydrochloric acid.

*Excess of Alkali in Decolourising Chlorides.*

It is useful to know the excess of alkali in decolourising chlorides, especially the soda in excess in chloride of soda, because on this quantity of soda depends the stability of the chloride and the activity of its bleaching power.

The following is one method used : Ammonia is added to the chloride of soda, which converts the chlorine into hydrochloric acid, and this hydrochloric acid converts the chloride of soda into sodium chloride reactions represented by the following equations :—



It must be observed that the soda only of the hypochlorite of soda is transformed into chloride of soda by the ammonia, and that the soda in excess is not attacked. The solution is then boiled to expel ammonia. Water is added to make up the original volume, and the soda in excess is determined by titration.



## CHAPTER XV.

### CHLORINE AND DECOLOURISING CHLORIDES.

CHLORINE.—*Physical Properties—Chemical Properties—Chlorine Water.*

CHLORIDE OF LIME.—*Chloride of Lime in Powder—Its Properties—Composition—Exhaustion of Chloride of Lime with Water—Weisbach's Dissolving Plant—Liquid Chloride of Lime.*

CHLORIDE OF SODA.—*Composition—Different Methods of Production—Manufacture of Chloride of Soda by the Reaction of Carbonate of Soda on Chloride of Lime—Proportions—Plan of Installation—Manufacture—Testing—Preparation of Chloride of Soda by the Action of Caustic Soda on Chloride of Lime—Proportions—Working Instructions—Preparation of Chloride of Soda by the Action of Sulphate of Soda on Chloride of Lime.*

BROCHOKI'S CHLOROZONE.—*Description and Properties—Professor Mills's Researches on the Nature and Properties of Chlorozone.*

VARIOUS DECOLOURISING CHLORIDES.—*Hypochlorites of Potash, of Magnesia, and of Zinc—Cotelle's Hypochlorite.*

COMPARISON OF CHLORIDE OF LIME AND CHLORIDE OF SODA.—*Economy—Safety—Bleaching Power.*

#### CHLORINE.

*Physical Properties.*—Chlorine is a greenish yellow gas at the ordinary temperature. One litre of chlorine weighs 3·17 grammes at 0° C. Its density compared with air is 2·45; its

atomic weight is 35.5; its atomic volume is 2. Inhaled in small quantities it produces irritation of the bronchial tubes; inhaled in larger quantities it gives rise to the vomiting of blood. (*Antidote*.—Inhale the vapours of alcohol or ether and drink milk.) Chlorine liquefies at 0° C. under a pressure of 6 atmospheres. Chlorine dissolves in water, yielding chlorine water. The solubility of chlorine in water is very feeble, and its solubility is modified very rapidly by elevation of the temperature.

One litre of water absorbs at—

DEGREES C.	LITRES CHLORINE.
0 - - - - -	1.430
8 - - - - -	3.040
10 - - - - -	3.000
17 - - - - -	2.370
35 - - - - -	1.610
50 - - - - -	1.490
100 - - - - -	0.150

When a rapid current of chlorine is made to pass through a condenser it deposits crystals of hydrated chlorine at about 0° C. These crystals may be collected, placed in a tube, the tube sealed, and heated to 38°. Decomposition of the hydrated chlorine takes place and liquid chlorine is obtained under its own pressure.

*Chemical Properties*.—Chlorine possesses very energetic chemical affinities. It combines directly with hydrogen and the metals with disengagement of heat. In sunlight it slowly decomposes water with disengagement of hydrochloric acid. Chlorine eliminates hydrogen from organic matters, and in consequence of this property is used as a disinfectant. It destroys colouring principles. The theory of its action is not very well known, but it is probable that it acts as an oxidising agent with liberation of oxygen. This oxygen in the nascent state transforms the colouring matter and bleaches it.

*Chlorine Water*.—Chlorine water obtained by bubbling a current of chlorine through water may be used in bleaching.

But this method brings in its train complications and difficulties that the bleacher may obviate by the use of alkaline hypochlorites, which are endowed with the same decolourising properties as chlorine itself.

#### CHLORIDE OF LIME.

*Chloride of Lime in Powder.*—*Properties.*—Dry chloride of lime has the same appearance as slaked lime. It ought to be pure white and of a uniform state of division. It has a peculiar odour due to hypochlorous acid, a body with altogether different properties.

When exposed to the air it slowly attracts moisture and becomes deliquescent. Chloride of lime which rapidly becomes moist in contact with the air, or is in a milky state as it comes from the casks, ought to be regarded as a deteriorated or badly manufactured article. Beaten up with a small quantity of water it yields a kind of lumpy paste. In a large quantity of water—about fifteen times its own weight—it partially dissolves, leaving a muddy residue. The dissolved portion only is endowed with bleaching properties.

Air, light, increase of temperature partially decompose chloride of lime and reduce its strength. Instances of spontaneous decomposition are quoted where the containing vessels have been shattered by the explosion. This is, however, comparatively rare, and is perhaps due to imperfect manufacture.

*Composition.*—Chloride of lime is made by passing a current of chlorine over slaked lime in a suitable state of division contained in closed chambers. The lime absorbs the chlorine and combines with it. The manner in which its component elements are combined the one with the other has been the subject of many scientific discussions, which have not resulted in any decided conclusion.

One theory is that it consists of hypochlorite of lime,

$\text{CaO-O-Cl}$ , and of chloride of calcium,  $\text{CaCl}_2$ . It always contains a certain proportion of uncombined or unattacked lime. According to this theory, chloride of lime contains an active chlorine principle endowed with decolourising properties and an inert chlorine ingredient of no use whatever in bleaching.

A second theory—that of Kolb—is that a compound having the formula  $\text{CaOCl}$  is formed, which is chloride of lime properly so called.

*Exhaustion with Water.*—A suitable plant which answers very well for dissolving chloride of lime is shown in Fig. 12 (1).

A.—Small tank into which the chloride of lime is dropped and in which it is beaten up with a very small quantity of water by means of a pestle or a mechanical agitator. The orifice is fitted with a metallic sieve so that only chloride of lime in the requisite state of fine division may pass through. The lumps, grit, etc., are beaten up afresh.

B.—Oval tank to receive the chloride of lime made into a pasty condition in the vessel A. This paste is diluted with water in the basin, B; the proportion generally used is 120 to 150 gallons for 100 lb. of chloride of lime. Mixture is effected by putting in motion two mechanical agitators working in contrary directions for about four hours, after which the whole is left to settle during the night, and in the morning the liquid is drawn off into the tank C.

The mud deposited at the bottom retains liquid chloride; it is washed with water, putting the agitators in motion. It is then allowed to settle and the liquid is used to treat the next batch of chloride of lime, and the residual mud transferred to the rubbish heap. If thought desirable the deposit may be washed a second time.

The clear liquid to be used in bleaching is syphoned off and the wash water pumped back.

As will be seen, the operation is very simple. The only

point to be observed is that care must be taken to see that all the lumps are well broken up. In many bleach works the chloride of lime is simply run into the tank B, and beaten up

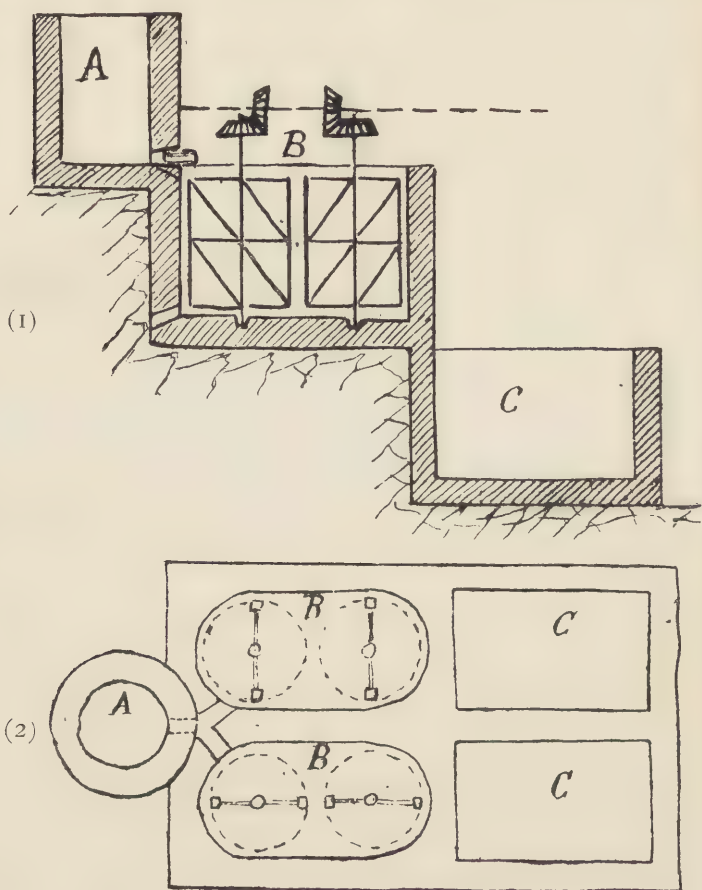


FIG. 12.—Plant for dissolving bleaching powder in water.

with the agitators. The author recommends the tank A for breaking up the chloride, because chloride of lime in lumps dissolves with difficulty, and mere agitation with water is not sufficient.



It cannot be too strongly recommended to take especial care in the decanting or syphoning off, so that only the perfectly clear liquid be used. Almost all the mishaps that occur in the use of chloride of lime arise from the fact of its having had lime in suspension, and it needs only a very small quantity of lime to injure the material to be bleached.

*Weisbach's Dissolving Plant.*—The above method is that most usually adopted in France. The firm of Ch. Weisbach of Chemnitz manufacture a special dissolving plant, which the author considers preferable (see Fig. 12 (2)).

This plant is used to mix the chloride of lime and water, whilst at the same time the lumps dissolve better. It consists of a wooden compartment lined with lead, with a tap for running in the water and another for the discharge of the liquid chloride, and a hole in the bottom (closed by a plug when at work) for washing out the residue. Inside is a sheet-iron drum lined with lead and zinc. This drum is pierced with small holes and is furnished with a hinged lid for the introduction of the chloride of lime. The drum is mounted on a shaft carrying pulleys, outside the reservoir, to receive the driving strap or belt that imparts the rotatory movement to the drum. The tap for running off the liquid chloride is fixed some distance from the bottom, so that none of the mud is run off with the liquid.

*Liquid Chloride of Lime.*—Chloride of lime in powder is very convenient for transport, but it always contains a large excess of lime. When chloride of lime is exhausted with water there remains in suspension an abundant white precipitate, which is nothing more nor less than calcium hydrate (slaked lime).

If this solution be allowed to stand the lime falls to the bottom, and a clear greenish yellow liquid is obtained containing hypochlorite of lime and calcium of chloride.

If, instead of allowing the solution to deposit the lime, a

current of chlorine be passed through it in the cold, the lime in suspension gradually dissolves and a perfectly clear liquid is obtained. The liquor then contains nothing but hypochlorite of lime and calcium of chloride. From the point of view of utilising the lime the liquid chloride is the more rational, and it is the more easy to prepare.

*Preparation.*—A milk of lime is placed in a bonbonne (a large Woulf's bottle presumably) or in a covered vat and a current of chlorine passed through.

In order to avoid pressure the current of chlorine is led to the surface of the bath and the liquid set in motion by an agitator.

Care is taken not to exceed a temperature of  $30^{\circ}$  to  $35^{\circ}$  C. at the most, so as not to decompose the chloride, which would yield chlorate. The operation should be stopped before all the lime is dissolved so as to avoid decomposition. The liquid, after clarifying, should not have a greater gravity than  $17^{\circ}$  Baumé. Between  $13^{\circ}$  and  $15^{\circ}$  is the general limit.

One hundred and fifty pounds of chloride of lime are used for 100 gallons of water, and 10 lb. of lime are left undissolved. Sometimes a little chlorate is obtained owing to the temperature of the bath being allowed to rise too high, or because too much lime has been dissolved.

When the process is finished the chloride is drawn off, allowed to settle, and the clear liquid syphoned off.

#### CHLORIDE OF SODA.

When a current of chlorine is passed into a solution of soda, chlorine is absorbed with evolution of heat, and a greenish yellow liquid results.

Works on chemistry give the following reaction :—



There is thus formed one equivalent of hypochlorite of soda and one equivalent of sodium chloride.

There may, however, be grounds for admitting that there

is formed a compound having the formula  $\text{NaOCl}$ , as Kolb has indicated for chloride of lime,  $\text{CaOCl}$ .

If care be not taken to always maintain an excess of soda, and that the point of saturation be not passed, the chloride decomposes very rapidly with disengagement of gas bubbles.

Thus a solution commencing to decompose fell in an hour from 20 chlorometric degrees to 2 chlorometric degrees.

*N.B.*—The author uses the term chloride of soda by analogy with the expression chloride of lime, and designates by that description the compound resulting from the combination of chlorine with soda, no matter whether this compound may consist of a mixture of hypochlorite of soda,  $\text{NaOCl}$ , and chloride of sodium,  $\text{NaCl}$ , or of a compound having the formula  $\text{NaOCl}$ .

*Different Methods of Producing Chloride of Soda (Sodium Hypochlorite).*—The use of chloride of soda presents great advantages in bleaching, more especially as far as safety is concerned. As this substance only exists in the liquid state dissolved in a large quantity of water, its transport is costly; different methods of preparing it in bleach works will therefore be explained.

The principle of the reaction is the following: When a salt of soda is caused to react on chloride of lime, hypochlorite of soda is formed, and the corresponding lime salt is precipitated. For example, if carbonate of soda be used a solution of hypochlorite of soda results, with precipitation of carbonate of lime according to the following equation:—



*Preparation of Chloride of Soda by the Reaction of Carbonate of Soda on Chloride of Lime.*

*Proportions.*—In order to find the quantity of carbonate of soda required to transform 100 lb. of chloride of lime into chloride of soda the following calculation is made:—

One hundred *kilogrammes* of chloride of lime testing 102 chlorometric degrees, for example, react according to the definition of the chlorometric degree as if they contained 100 *kilogrammes*  $\times 102^\circ = 10,200$  *litres* of chlorine or a weight of chlorine equal to  $10,200 \times 0.00317$  *kilogramme* = 32.334 *kilogrammes*. In fact, 0.00317 *kilogramme* represents the weight of a *litre* of gaseous chlorine at the temperature of  $0^\circ$  C.

The equivalent of chlorine  $\text{Cl}_2$  in weight is 71, and whatever may be the manner in which it is combined with lime it requires one equivalent of carbonate of soda, 106, to each equivalent of chlorine to transform it into chloride of soda.

The following proportion will give the weight, P, of carbonate of soda required to transform 100 parts of chloride of lime into chloride of soda :—

$$\frac{P}{32.334} = \frac{106}{71} \quad P = \frac{106 \times 32.334}{71} = 48.3 \text{ kilos.}$$

To make sure that no lime remains, this quantity must be increased, to neutralise the excess of lime dissolved in the chloride of lime. A good proportion to use is 55 lb. of Solvay soda ash for 100 lb. of chloride of lime.

The quantity of water used to effect solution depends on the degree of concentration which it is desired to obtain. Actual practice demonstrates that it is not desirable to go beyond 8 to 9 chlorometric degrees. The quantity of water X will therefore be

$$X \times 8^\circ = 100 \text{ kilos.} \times 102^\circ \quad X = \frac{10,200}{8} = 1,275 \text{ litres.}$$

*Description and Arrangement of Plant.*—The illustration, Fig. 13, shows a very convenient arrangement for the preparation of chloride of soda. The tanks are of mason work, lined with cement, and placed at different levels. On the top flat or stage an agitator with blades mechanically mixes the chloride of lime and water. The work of the agitator may be replaced by that of a man who beats up the chloride of lime



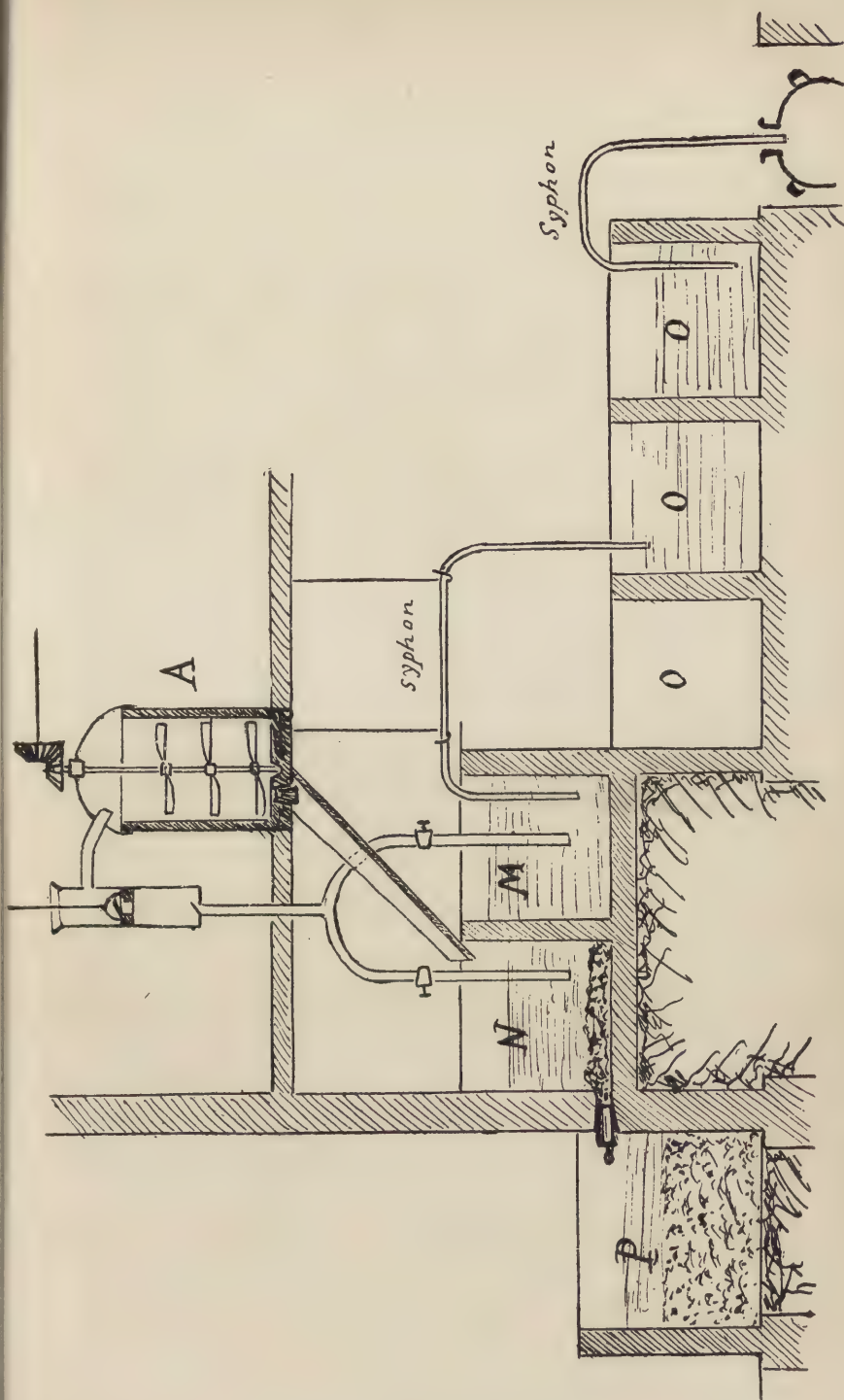


FIG. 13.—Preparation of "Chloride" of Soda (Sodium Hypochlorite) from Bleaching Powder and Soda Ash.



with a wooden pestle or chopper. The important thing is not to leave any lumps. When the chloride of lime is well beaten up, it should be run into the lower tank through a metallic sieve, thus ensuring that the whole has been reduced to a suitable state of division. The solutions are run from one tank into another by means of syphons. The wash water is pumped up to the top tank to be used in the exhausting of a fresh quantity of chloride of lime.

*Manufacture.*—In order to make 900 to 1,000 *litres* of chloride of soda of 8 chlorometric degrees the process is conducted as follows. Dissolve in a tank 55 *kilogrammes* of carbonate of soda. In winter it is advisable to use tepid water. Run in gradually into the mixer, A, 100 *kilogrammes* of chloride of lime, which is beaten up with the wash water of previous operations taken from the vat N by the pump. After the 100 *kilogrammes* of chloride of lime have been run in, keep the mixer going for two hours and then run the solution into the vat M, in which the carbonate of soda has been previously dissolved. Fill the vat to the desired height so as to have 1,275 *litres* with the wash waters of the vat N, and mix the whole well. Let stand till morning, and with a syphon run the clear liquid into one of the vats O. Wash the deposit in the vat M, and allow to stand. The clear liquid is used to exhaust the chloride of lime of the next operation. The residue is then run into a rubbish receiver, P. Allow the liquid in the tanks O to stand until the morning and then syphon off into carboys, being careful only to run off the clear liquid.

*Testing.*—The chlorometric strength or degree is estimated by one or other of the different methods of titration used in chlorometry. If the resulting product does not correspond with the strength aimed at the cause for this defect must be found. To ascertain whether enough carbonate of soda has been used a sample of the clear solution is taken, and a few

drops of carbonate of soda are added. If there be a precipitate there is unattacked lime remaining in excess, and enough carbonate of soda has not been used.

It is desirable that there should always be carbonate of soda in excess, but in small quantity, because in the first place it is a useless expense of carbonate of soda, and secondly because too great an excess of carbonate of soda reduces the bleaching power of the chloride of soda. How to estimate the amount of alkali in excess is described in Chapter XIV.

*Preparation of Chloride of Soda (Sodium Hypochlorite) by the Action of Caustic Soda on Chloride of Lime.*

When it is desired to make chloride of soda of high strength, that is to say of about 30 chlorometric degrees, caustic soda must be used instead of carbonate of soda.

*Proportions.*—The calculation of the quantity of caustic soda required to transform a known weight of chloride of lime is analogous to that given for the carbonate. Supposing it is desired to transform 100 *kilogrammes* of chloride of lime 102° chlorometric strength into chloride of soda. These 100 *kilogrammes* of chloride of lime contain :—

$$100 \text{ kilos.} \times 102^{\circ} \times 0.00317 \text{ kilo.} = 32.334.$$

Now the equivalent of chlorine is 71, that of soda is 62, hence the weight X of soda required to combine with 32.334 *kilogrammes* of chlorine is given by the following calculation :—

$$\frac{X}{32.334} = \frac{62}{71} \quad X = \frac{62 \times 32.334}{71} = 28.23 \text{ kilos.}$$

These 28.23 *kilogrammes* represent anhydrous sodium oxide  $\text{Na}_2\text{O}$ . Commercial caustic soda always contains water and other impurities. This soda is sold according to the Descroizilles degree; by multiplying the Descroizilles degree by 0.632 the percentage of anhydrous soda is obtained. Supposing caustic soda testing 110° Descroizilles is being used, this soda

contains  $110 \times 0.632 = 69$  per cent. of soda  $\text{Na}_2\text{O}$ . Consequently the weight of the 28.23 *kilogrammes* must be increased in the proportion of  $\frac{100}{69}$ , thus :—

$$\frac{28.23 \text{ kilos.} \times 100}{69} = 41 \text{ kilos.}$$

of soda of 110° Descroizilles.

If it be desired to produce chloride of soda of 8 to 9 chlorometric degrees, the carbonate of soda process may be followed; but if a high strength be desired recourse must be had to a process of successive enrichment and methodical exhaustion of the residual mud.

*Process.*—The arrangement of the plant is the same as that shown in Fig. 13, but instead of two reagent tanks four or five are used.

The caustic soda of 110° Descroizilles is dissolved in a cast-iron vessel in the proportion of 330 *kilogrammes* of soda to 1,000 *litres* of water, say 330 lb. per 100 gallons.

The charge of chloride of lime is run into the mixer and dissolved in the liquid pumped from the tanks—a liquid already enriched with hypochlorite of soda by methodical washings.

There is placed in the tank where the reaction takes place the quantity of caustic soda solution required to transform the chloride of lime—(beaten up with the washings in the mixer)—into chloride of soda, and the necessary volume is made up with washings from a neighbouring vat. The whole is then agitated very energetically, then decanted, and the clear liquid consisting of concentrated hypochlorite of soda is syphoned off. The method of manufacture established, the other tanks or vats contain respectively a liquid which diminishes in richness in chloride of soda from one vat to the other. To methodically exhaust the muds the clear liquid from each vat is run into the succeeding one in such a manner that it becomes enriched in contact with muds richer and richer in chloride of soda.

The vat containing the poorest mud is filled with water; this done, all the vats are stirred energetically and allowed to stand.

Decantation over, the liquids are run from one vat into the next, the mud of the last vat, sufficiently exhausted, is thrown away, and it is this vat which is free for the reaction of the next batch of chloride of lime and caustic soda.

The quantities of chloride of lime and caustic soda and the volume of liquid to use depend on the degree of concentration desired in the hypochlorite of soda. The calculation of these is easy, as shown above. This plant and method is not suitable for obtaining a greater strength than 30 to 33 chlorometric degrees.

*Preparation of Chloride of Soda by the Action of Sulphate of Soda on Chloride of Lime.*

In order to transform chloride of lime into chloride of soda, sulphate of soda may be used in place of the carbonate. Insoluble sulphate of lime is formed.

The advantage consists in the low price of sulphate of soda, which is a by-product and which may be obtained at 4 francs the 100 kilogrammes.

Low-priced sulphate of soda contains many impurities, and the resulting chloride of soda is more or less impure.

Sulphate of lime deposits badly. To aid decomposition a mixture of carbonate and sulphate of soda is used, the carbonate of lime carries down the sulphate of lime in its train, and the liquid clarifies much more rapidly.

The calculation of the quantity of sulphate of soda required to transform a given weight of chloride of lime into chloride of soda is made in a manner analogous to that indicated for carbonate of soda or caustic soda. It is evident that the percentage of anhydrous sulphate ( $\text{Na}_2\text{SO}_4$  equivalent 142) in the sulphate used must be known.

The plant is the same as that already described.

## BROCHOKI'S CHLOROZONE.

M. de Brochoki put on the market some twenty years ago a chloride of soda to which he gave the name of chlorozone.

This product is obtained at a regulated cold temperature by saturating a solution of caustic soda of a greater or less degree of concentration by a current of chlorine which he says is previously peroxidised.

It is a clear limpid liquid producing neither deposit nor formation of crystals at the bottom of the vessels in which it is contained. According to the description of this product—

“At the density of 1·385 it acquires a decolourising power of above 120 chlorometric degrees, and exposed in this condition to a temperature of 1° C. it crystallises in mass in beautiful rhomboidal crystals of a bright yellow colour.

“Chlorozone is put on the market at a density of 1·250. It then contains:—

	PER CENT.
Chlorine - - - - -	12·68
Oxygen - - - - -	5·82
Sodium - - - - -	8·62
Water of combination - - - - -	3·38
Water of solution and other substances - - -	69·50
	<hr/> 100·00 <hr/>

“At this density 1 *litre* of chlorozone tests 50 chlorometric degrees, that is to say, it contains the equivalent of 50 *litres* of chlorine per *litre*.”

The chlorozone made in the chemical works of Kuhlman of Lille has a density varying from 1·18 to 1·20. It tests 35 chlorometric degrees, that is to say it contains the equivalent of 35 *litres* of chlorine per *litre*.

The author used chlorozone during a period of four years in a bleach works of fine linen and cotton fabrics, and as a result of his experience he is able to say of this product that it may be used by bleachers with the greatest elements of



safety or sense of security from injury being done to the fabrics. He has used it both in the hot and the cold, and its use has always been attended with the same excellent results.

This product runs from 14 to 18 francs the 100 *kilogrammes*, on account of the cost of carriage. Weight for weight it contains three times less chlorine than chloride of lime. Its relatively high price is accounted for by the fact that it is not yet extensively used.

*Researches on the Nature and Properties of Chlorozone by  
Professor Mills, D.Sc., F.R.S.*

The author believes that it would be interesting to quote here what Professor Mills has said about chlorozone, not only as showing what may be done with this product, but more especially to point out what conception one ought to have of the products due to the absorption of chlorine by alkalies, and also what advantage may be obtained by the use of chlorine in the hot.

*The Dyer and Calico Printer* quotes Professor Mills' opinion as follows:—<sup>1</sup>

“Our knowledge of the oxygenated compounds of chlorine is so far from being complete that we cannot say with precision what chlorozone is, or to what series of reactions it owes its origin.

“At first sight one would be led to suppose that this product would be a hypochlorite of soda (*eau de Javelle*), in other words, that it would be identical with the product obtained by treating a solution of chloride of lime with carbonate or sulphate of soda. The supposition can be easily decided by experiment.

“If solutions of chlorozone and hypochlorite of soda of equal density and chlorometric strength produce the same

<sup>1</sup> Translated from M. Tailfer's *Treatise*, and not as it appeared in *The Dyer and Calico Printer*.

effect on colouring principles, they are identical ; if not, they are different.

“ A piece of stuff dyed with Turkey red was steeped in a sample of chlorozone of density 1·0686, and this bath brought slowly to the boil : the colour was bleached in three minutes. A similar experiment with hypochlorite of soda produced only a partial decolouration after very prolonged ebullition.

“ Chlorozone and hypochlorite of soda are not, therefore, identical. But it is right to say that highly concentrated chlorozone, kept for a long time, would not probably produce the same results as obtained by the bleaching of the stuff dyed with Turkey red.

“ A dilute solution of chlorozone preserves its properties much longer. I have never known exceptions. Moreover, the peculiar smell and the yellowish colour of chlorozone are altogether different from those of solutions of hypochlorite of soda of the same density and chlorometric strength.

“ The process of the preparation of chlorozone is such that chlorine, or a more or less oxygenated compound of chlorine, is produced, which is absorbed, perhaps not too intimately, by the caustic soda.

“ Finally, it would appear probable that chlorozone is essentially a hypochlorite of soda more or less charged with chloric peroxide, and perhaps with lower oxides.

“ If this supposition be true, an analogous chemical substance would be a solution—easily prepared in actual practice—of caustic soda alkaline to turmeric paper, but containing free iodine in solution.

“ The use of chlorozone is very simple ; the goods, sometimes after an alkaline lye-boil, are steeped in a solution of chlorozone more or less strong, and left there until the desired effect is obtained.

“ If it be necessary to use heat, the heat is applied to the

bath and its contents, but after having maintained it for some time at the ordinary temperature. It is not necessary to heat above  $60^{\circ}$  C., except it be desired to economise time, because chlorozone becomes very active at a temperature of  $50^{\circ}$  to  $60^{\circ}$  C.

“Or again, the stuff is soured, washed as usual, and sometimes the operation is repeated on the same goods.

“There is reason to believe that sunlight assists the bleaching action of chlorozone. Bleaching by chlorozone is generally done in the following solutions :—

“1. Bath A, 1.5 chlorometric degree.

“2. Bath B, 3.0 chlorometric degrees.

“More dilute solutions may be used for less important work ; for example, 0.30 to 0.50 chlorometric degree.

“I do not give the above and following details in order that they should be adopted in their entirety, but rather that they should form a guide to those in the trade who make use of chlorozone.

“They may rest assured that in operations on a large scale more dilute solutions than those indicated above will answer perfectly well.

“I may add that in cases where the sample is caustic, a little bicarbonate of soda is the best agent to apply.

#### *Cotton Bleaching.*

“I have perfectly bleached a piece of cotton in the following manner : The coarse fabric having been boiled for an hour in a solution of soda crystals (1 in 100), wrung and washed, was plunged in a bath of chlorozone A for two and a half hours at  $62^{\circ}$  C., then again wrung and acidulated with hydrochloric acid for an hour. The fabric was again washed, etc., . . . and plunged in a second bath A, at  $60^{\circ}$  C., for three hours, then wrung, soured, washed and dried.

“The result was quite equal to the ordinary average ob-

tained by the processes so long in use. The duration of the process was about nine hours. The greater part of this loss of time was due to the lye-boiling.

#### *Yarn Bleaching.*

"As regards yarn, chlorozone may be used in the ordinary manner as a substitute for chloride of lime. The following are the details of the operation: Boil your yarn in lye, and allow to cool during the night as usual. Wash and wring. Prepare then a bath of 100 volumes of water at about  $95^{\circ}\text{C}.$ , add thereto 10 volumes of ozone or weak chlorozone, rinse (this bath will test about 0.4 chlorometric degree), and agitate rapidly. Plunge the goods therein, and allow to cool for an hour and stir from time to time. Withdraw, wring and acidulate for an hour. Result: a brilliant white.

#### *Linen Bleaching.*

"I have bleached linen the most brilliant white in the following manner:—

"I prepared a chemick diluted to the strength A, and immersed the linen therein in the cold. The effect is produced in about an hour. At the end of three hours I heated the bath and its contents to  $54^{\circ}\text{C}.$  during an hour, took out the linen, rinsed it, passed it through acid, and rinsed it. Four hours sufficed for this operation. To make certain whether a better result still might not be obtained, I immersed the linen again in bath A for five hours in the cold, and one hour at  $55^{\circ}\text{C}.$ ; the operation finished, I noticed but little difference after the second treatment.

"The total loss was 16.2 per cent. During these operations the linen took up a little organic chlorine, the greater portion of which is probably introduced at the time it passes through the acid.

"Any antichlor, such as sulphite or hyposulphite of soda, ammonia, etc., will remedy this inconvenience.

*Bleaching of Sheetting.*

"An excellent white may be obtained in the following way: Heat your unbleached sheetting to  $100^{\circ}$  C. for an hour in a solution of soda crystals (1 in 100), wash in water.

"Pass to the bath A, leave for two and a half to three hours in the cold; heat the bath and its contents to  $50^{\circ}$  C. for an hour; take out the sheetting and rinse it. The final operation consists in passing through acid as usual, hydrochloric acid being better than sulphuric.

"The sheetting is washed, passed through another chemick, soured and washed. In a special experiment the loss of weight was 1.37 per cent., which is insignificant; the sheetting is not shrunk and does not lose any of its textile strength. The operation lasts less than nine hours. It is probable that in many cases the boiling with dilute alkaline lye may be suppressed, at least as far as cotton is concerned.

"Three-quarters white, second quality, may be obtained by a single heating for two hours at  $70^{\circ}$  in a bath of chlorozone of 1 volume to 120 volumes of water.

"The sheetting, as in ordinary bleaching, takes up a little organic chlorine.

"The bleaching process may be conducted in many cases in the following manner: Prepare bath A, steep your stuff therein for three hours at the ordinary temperature. A visible effect will be produced in half an hour; take out your stuff, wring, dry and wash.

"Some yellow spots may be formed, which will disappear during drying. The stuff will become whiter after several days, and if there be no great pressure of work, a second chemick, followed by washing and drying, will be very advantageous."

## VARIOUS BLEACHING CHLORIDES.

*Hypochlorite of Potash.*—This chloride is obtained in the same way as hypochlorite of soda and it has analogous



properties. It is more rarely used, as potash is dearer than soda.

*Hypochlorite of Magnesia.*—This is obtained by the action of sulphate of magnesia on chloride of lime. This product is almost neutral; its bleaching power is very active. The solidity of the fabric is as well preserved as with chloride of lime or soda. Hypochlorite of magnesia decomposes very quickly. The author has prepared it of 8 chlorometric degrees and at the end of two days it had run down to 2 degrees. Decomposition went on afterwards, but more slowly.

*Hypochlorite of Zinc.*—This is prepared by the action of sulphate of zinc on chloride of lime. The bleaching power is very energetic, but the solidity of the goods to be bleached is more affected than with alkaline hypochlorites.

*Cotelle's Hypochlorite.*—The author has lately had occasion to make a particular study of a hypochlorite of soda made by M. Cotelle, manufacturer at Ponthierry (Seine-et-Marne, France). This hypochlorite of soda is produced by the action of sulphate of soda on chloride of lime. It is sold on the market at 33° to 35° chlorometric strength and has a density of 23° by Baumé's hydrometer. The method of manufacture is a trade secret. This product being almost neutral, and containing not a trace of either caustic or carbonated alkali, is highly esteemed for the bleaching of coloured fabrics the colour of which is attacked by alkalies, whether caustic soda or carbonate of soda. This product is employed in the bleaching of silk under conditions where the ordinary hypochlorites could not be used.

#### COMPARISON OF THE CHLORIDES OF LIME AND SODA FROM THE POINT OF VIEW OF ECONOMY, SAFETY, AND BLEACHING POWER.

*Economy.*—From an economical point of view chloride of lime is the cheapest. In fact the price of chloride of lime

varies in different countries between 17 and 25 francs the 100 *kilogrammes*.

If we take the chloride of lime at 100 chlorometric degrees, the price of the *litre* of chlorine will be for chloride of lime at 25 francs the 100 *kilogrammes*

$$\frac{25}{100^\circ \times 100 \text{ kilos.}} = 0\cdot0025 \text{ fr.,}$$

for the chloride of lime at 17 francs the 100 *kilogrammes*

$$\frac{17}{100^\circ \times 100 \text{ kilos.}} = 0\cdot0017 \text{ fr.}$$

This price must be increased 10 per cent. in order to make allowance for the chlorine carried away in the residue, which will bring the price of the *litre* of chlorine up to

$$0\cdot0025 \text{ fr.} + 0\cdot00025 \text{ fr.} = 0\cdot00275 \text{ fr. for the chloride at 25 fr.}$$

$$0\cdot0017 \text{ fr.} + 0\cdot00017 = 0\cdot00187 \text{ fr. for the chloride at 17 fr.}$$

The price of the chloride of soda of 30 chlorometric degrees per *kilogramme* may be estimated at 12 francs the 100 *kilogrammes* in Belgium, 15 francs in the north and east of France, 18 francs in the west and south.

The price of the *litre* of chlorine runs therefore :—

$$\text{In Belgium } \frac{12 \text{ fr.}}{30^\circ \times 100 \text{ kilos.}} = 0\cdot004 \text{ fr.}$$

$$\text{In France, North and East } \frac{15}{30^\circ \times 100 \text{ kilos.}} = 0\cdot005 \text{ fr.}$$

$$\text{In France, West and South } \frac{18}{30^\circ \times 100 \text{ kilos.}} = 0\cdot006 \text{ fr.}$$

The chloride of lime is thus cheaper, and on this account is preferably employed in the bleaching of the larger numbered yarns and common sheeting. It has the disadvantage of being injurious to the workman engaged in beating it up with water, and of leaving a residue which is often very cumbrous.

The chloride of soda being sent out in carboys, there is no necessity to exhaust it with water before use. But as it is a liquid product which does not often contain more than 30 *litres* of chlorine per *kilogramme*, it is more difficult and more

costly to transport than chloride of lime in powder, which contains at least 100 *litres* of chlorine per *kilogramme*.

*Safety*.—Chloride of lime (solution) ought to be perfectly clear before being used. If this precaution do not receive the attention which it deserves, and should it contain lime in suspension, even in small quantity, the fabrics are seriously deteriorated. Moreover, even clear liquid chloride of lime always contains a little lime in solution, and this lime exerts an injurious action on the fabric. Chloride of soda, on the other hand, has soda for its base—a perfectly soluble substance which has not the injurious action on fabrics which lime has. Experience has proved that fabrics treated with chloride of soda preserve their solidity better.

When it is a case of bleaching fine fabrics, the author believes that there can be no question of hesitancy or doubt, and that chloride of soda ought to be preferred. The difference in price will be more than compensated by safety in use and the better preservation of the bleached fabric. In the case of common fabrics, the remuneration for bleaching which is hardly profitable, it must be left to the bleacher to decide for himself, making sure that he can rely on his staff, and that only perfectly clear chloride of lime be used. In factories where hydraulic power is available it would be of great profit to use electrolytic chloride of sodium, for in that case its price is lower than chloride of lime.

*Bleaching Power*.—The more easily the decolourising chlorides are decomposed, the more active they are, and, on the other hand, this decomposition takes place the more rapidly the chloride approaches the neutral state. To this may be attributed the difference which exists in the rapidity of action of chloride of lime and chloride of soda.

Clear liquid chloride of lime only contains in solution a small quantity of free lime, which corresponds to the feeble solubility of lime in the chloride.

Chloride of soda, on the other hand, contains free soda in very variable and sometimes considerable proportions.

Chloride of lime acts therefore more energetically than chloride of soda, but both these chlorides may be reduced to a state of equal activity by neutralising by an acid the base in solution. But this must be done with caution, as the acid first neutralises the free bases and then decomposes the hypochlorite with liberation of chlorine.

It is sometimes advantageous to diminish the bleaching action of chloride of soda, as for example in the treating of fabrics containing coloured patterns which it is desired to preserve. Carbonate of soda is then added to the liquid to render it alkaline, or better still bicarbonate of soda, which transforms caustic soda into carbonate of soda.

## CHAPTER XVI.

### WATER.

QUALITIES OF WATER.—*Rain Water—Terrestrial Waters—Selenitic Waters—Calcareous Waters—Mineral Waters—Muddy Water—Stagnant Water—Rapid Process for Distinguishing Water.*

HARDNESS.—*Determination of the Degree of Hardness—Description of the Method of Analysing Waters.*

DERVAUX PURIFIER.—*Distributing Apparatus—Saturating Apparatus—Decanting Apparatus.*

TESTING THE PURIFIED WATER.—*Necessary Testing Instruments—Testing the Lime Water—Testing the Alkalinity of the Water—Testing the Water in the Boilers.*

DIFFERENT PLANT FOR PURIFICATION.—*Filters.*

THE quality of water is of great importance in bleaching, and it is the difference in the waters used which explains why bleach works which use the same process do not obtain equally beautiful whites.

There are chemical processes in existence for correcting the nature of waters. Their application on a grand scale would entail in some instances too great an expense, but in certain more restricted cases it may be found very advantageous to purify water—for example, the water used in soap scouring, or to feed the steam boilers.

If the bleacher wishes to have a complete analysis of the water he is using, the author advises him to consult a chemist, because it requires instruments and experience which the



bleacher does not generally possess. Some information as to the nature of different waters, and the inconveniences incidental to the saline matter which they contain, will now be given, and at the same time a description of some simple methods for the analysis of water and deducing therefrom the proportion in which the chemicals to be employed for its purification should be used.

### QUALITIES OF WATER.

*Rain Water.*—Rain water is the best which can be used for bleaching purposes, because it does not contain lime salts and because it dissolves soap very freely.

The rain as it falls from the clouds traverses the atmosphere, and in so doing becomes charged with soluble and insoluble matters. The soluble matters are the gases of the air—oxygen, nitrogen and carbonic acid. There is always a little ammonia, due to the decomposition of organic matters; a little nitric acid, due to the action of electric discharges in the regions of the clouds on the mixture of oxygen and nitrogen; ozone, due in the same way to the action of electricity on oxygen; finally, barely appreciable traces of mineral salts coming from the dust which the wind raises from the surface of the earth. The sodium chloride contained in rain water comes from the sea. The presence of these different bodies explains how rain water assists the bleaching of fabrics exposed on the grass.

Organic matter, coal and other dusts prevent the use of rain water on account of their soiling the fabrics; but if it be possible to collect it in cisterns and filter it through sand to get rid of the dust, a better water cannot be found.

*Terrestrial Waters.*—The waters of springs, rivers, lakes and ponds consist of water which has been in contact with the earth for a greater or less time. They contain soluble substances derived from the ground which they have traversed.

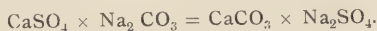
Waters are classified according to the nature of the salts and substances which they contain.

*Selenitic Waters.*—Selenitic waters contain the greater part of their lime as sulphate. Such are the waters of the Paris wells, which are sometimes saturated with sulphate of lime. They do not become cloudy on boiling, but form abundant precipitates with ammonium oxalate and chloride of barium.

They cannot be used for cooking vegetables because the lime present in such a large quantity combines with the vegetable casein or legumen of the envelope of haricot beans, peas and lentils, and this very hard calcareous compound does not soften on boiling.

They do not dissolve soap because they decompose it. Soap consists essentially of stearate of soda, which salts of lime convert into insoluble stearate of lime.<sup>1</sup> Soda lyes form, with the resinous or gummy matters of the fabrics, kinds of soluble soap; the selenitic water decomposes them in a manner analogous to that produced by soaps properly so called; and thus the object aimed at in washing—the removal of the substances dissolved by the lye—is not accomplished.

These waters may be rendered fit for industrial use and like purposes by the addition of carbonate of soda; carbonate of lime is formed, which precipitates, and sulphate of soda, which is comparatively harmless in small quantity.



The presence of sulphate of lime is most manifest in those springs which issue from selenitic strata.

The analysis of a Paris well showed it to contain 1·320 *gramme* of sulphate of lime per *litre*.

According to analysis made at Lyons by Dupasquier and

<sup>1</sup> The precipitated soaps are struck on to the fibre, and if not removed eventually show themselves after being dehydrated in the course of time, or by steam heat; they stain the fabrics in proportion to the depth of colour of the raw ingredients from which the soap was made.—Tr.

Seeligmar, the water of several springs of that town used for potable purposes contained 0·25, 0·942, and even 1·15 *gramme* of sulphate of lime per *litre*.

The water of streams and rivers contains a much smaller quantity, as is shown in the following table :—

Quantity of Sulphate of Lime per <i>litre</i> of Water.		
Water of the Seine	-	0·039 <i>gramme</i> .
" Rhône	-	0·005 "
" Saône	-	0·003 "
" Loire	-	0·002 "

*Calcareous Waters*.—Certain waters which have undergone greater pressure in the lower strata of the crust of the earth are charged with carbonic acid, and in their passage through calcareous rocks dissolve appreciable quantities of carbonate of lime as bicarbonate or acid carbonate. When they issue from the surface of the ground, the pressure diminishing, they lose carbonic acid and deposit carbonate of lime. The water of the stream of Saint-Allyre in Auvergne yields so abundant a deposit that an object plunged for several hours in that water becomes covered with a uniform solid layer of carbonate of lime.

Many deposits of carbonate or of phosphate of lime are formed by this method of slow precipitation. The encrustations deposited in conduit pipes by certain waters are produced in the same way.

These waters turn a solution of campeachy-wood blue, turn cloudy on boiling, and on exposure to the air or under the influence of lime water precipitate the excess of carbonic acid. They may be rendered potable and fit for domestic and industrial purposes by the following processes :—

1. Boiling, then setting at perfect rest and drawing off. There is thus disengagement of the free carbonic acid and the carbonic acid which formed the soluble bicarbonate, and the

insoluble carbonate is precipitated under the form of a white powder.

2. Agitation in contact with air. This mechanical method accomplishes the same end as the preceding.

3. Treatment by lime water until that liquid gives no further precipitate. The following reaction takes place :—



It is to the use of these waters that the calcareous deposits of steam boilers are due. The hardness of the deposits is such that a hammer and chisel are required to detach them from the sides of the boiler. This cause of deterioration is remedied by introducing potato peelings, clay, ammonium chloride, or carbonate of soda into the water. These substances prevent the aggregation of the calcareous deposit and enable it to be easily removed afterwards.

*Mineral Waters.*—These are divided into seven classes, according to the nature of the predominating ingredient :—

1. Alkaline waters contain alkaline bicarbonates.
2. Acidulated waters are characterised by the presence of carbonic acid gas.
3. Chlorinated waters contain sodium, potassium, or magnesium chlorides.
4. Sulphated waters are characterised by sulphate of magnesia or soda.
5. Sulphuretted waters contain alkaline sulphides.
6. Ferruginous waters owe their properties to the presence of iron.
7. Brominated and iodated waters contain alkaline bromides and iodides.

Mineral waters are seldom met with, and only in certain districts, where their presence prevents the establishment of a bleach works. Ferruginous waters are more frequent ; if they are highly charged with iron they are altogether unfit for bleaching purposes ; if they only contain a small trace of iron

the slight yellow colouration is removed by a hot sour with oxalic acid towards the end of the bleaching operations.

*Muddy Water.*—*Stagnant Water.*—Springs are generally limpid and the deeper their source the less liable they are to be cloudy. This is why they are preferred to the waters of rivers and ponds, even although they are often charged with calcareous principles.

River water is sometimes bright and at other times muddy from rain when it contains more or less earthy matter in suspension. In the latter case it is impossible to use it for washing fabrics, especially when they are nearly white. In those bleach works where no other water is available a filter is indispensable. It is equally necessary when the water—even spring water—contains in suspension substances which it has taken up from the rocks with which it has come in contact, —ochres, for example, which dye the fabrics yellow.

Stagnant water soon goes wrong in consequence of the development of lower organisms ; they are injurious in domestic use, and do not suit either for bleaching purposes, because they are not bright and because they communicate a bad smell to the fabrics.

*Rapid Tests for Water.*—A water in order to be more or less good for hygienic or industrial purposes ought to satisfy the following conditions :—

1. It ought to be clear, bright and limpid.
2. It ought to have no smell, and no disagreeable taste.
3. It should only leave a slight residue on evaporation.
4. It ought to dissolve soap well and form no curds with it.
5. It ought to cook vegetables without hardening them.
6. It should give no cloudiness when tested with nitrate of silver, nitrate of baryta or oxalate of ammonia.

These tests serve only to give a first indication of the value of a water. But more rigorous and precise methods must be adopted when submitting waters to a conscientious analysis.



## HARDNESS.

*Determining the Degree of Hardness (Hydrotimetry).*—The description of this method is taken from Olive's *Course of Hydraulics*. The solid substances in fresh water consist almost exclusively of salts of lime and magnesia. The other substances present are found in barely appreciable quantities. It is sufficient, therefore, to determine the former, which is done by estimating the hardness.

This process is based upon the property which soap possesses of giving a persistent lather with distilled water, whilst calcareous or dolomitic (magnesian) waters give no lather until all their salts have been precipitated as stearates of lime or magnesia.

This point being established, if soap be dissolved in alcohol and poured drop by drop into a calcareous water no lather is produced until the calcareous salt has decomposed a corresponding quantity of soap. To ascertain the richness of the water in calcareous salts, all that is required is a standard solution of soap. The method of working is as follows:—

A standard solution of soap is made by dissolving 50 grammes of white Marseilles almond oil soap in 800 grammes of 90 per cent. alcohol.

The solution thus obtained is filtered and 500 grammes of distilled water added. There is thus obtained 1,350 grammes of test liquor.

The test liquor made in this way contains in solution  $\frac{1}{4000}$  of its weight of calcium chloride, say 0.25 gramme of this salt per litre. It is moreover tested to ascertain its real strength.

A quantity of the liquid equal to 2.4 cubic centimetres is run into a hydrotimetric burette of a total capacity of 7 cubic centimetres, and the space occupied by the 2.4 cubic centimetres is divided into twenty-three divisions.

The test liquor is of such a strength that twenty-two of these divisions contain sufficient soap solution to neutralise 1 *centigramme* of calcium chloride. The No. 0 of these divisions, placed at the top of the burette, is not marked opposite to the first division, but to the second. It has been found, in fact, that the quantity of soap solution corresponding to this first division is necessary to produce a permanent lather in 40 cubic *centimetres* of distilled water. Below 22° the burette is marked in equal divisions.

Twenty-two of these divisions correspond to 1 *centigramme* of calcium chloride; each division, termed hydrotimetric, corresponds to a weight of calcium chloride equal to  $\frac{0.01}{22}$ .

As the test is always performed on 40 cubic *centimetres*, that is on the  $\frac{1}{25}$  of a *litre*, each hydrotimetric degree of soap solution used by these 40 cubic *centimetres* will represent a quantity of calcium chloride twenty-five times greater per *litre*. The test made on 40 cubic *centimetres* represents therefore for each hydrotimetric degree a weight of calcium chloride per *litre* equal to  $\frac{0.01}{22}$  *gramme*  $\times 25 = 0.0114$ , say 0.01 *gramme* of carbonate of lime for the same quantity of water.

It suffices, therefore, in order to ascertain the richness of a water in calcareous salts (supposed in the condition of calcium chloride), to multiply by 0.0114 the number of hydrotimetric degrees consumed by 40 cubic *centimetres* of the water to be tested.

As the molecular weights of calcareous salts are not very different, it can be taken for granted with sufficient exactitude for practical purposes that the analyses indicate the quantity of calcareous and magnesian salts whatever they may be. Thus a water which tests 28 hydrotimetric degrees contains 0.23 to 0.24 *gramme* of calcareous salts per *litre*.

The hydrotimetric apparatus of Boutron and Boudet, who were the first to use this method, imagined in principle

in the beginning of this century by the chemist Clarke,<sup>1</sup> consists of:—

1. A hydrotimetric or graduated burette constructed in such a manner that the circular mark at the top of the instrument shows the point to which it should be filled.

The division included between this circular mark and the 0° represents the quantity of liquor required to produce a lather with distilled water. The hydrotimetric degrees start from the 0°.

2. A test bottle of 60 cubic *centimetres* capacity and graduated at 10, 20, 30, 40 cubic *centimetres* by circular marks

3. A bottle of standard soap solution for hardness of water.

4. A flask of distilled water.

The above suffice for the generality of tests, but if it be desired to push the analysis further, and determine according to the Boutron and Boudet process the carbonic acid of the salts of lime and magnesia and the proportion of sulphuric acid in the condition of sulphate contained in the water, the apparatus ought to include besides:—

5. A bottle of ammonium oxalate solution (1 in 60).

6. A flask of nitrate of baryta titrated to 20° for 1 cubic *centimetre*.

7. A pipette divided into tenths of cubic *centimetres*.

8. A graduated flask.

9. Various accessories.

*Hydrotimetric Test.*—In order to test any water, 40 cubic *centimetres* is measured into the test bottle and the standard

<sup>1</sup> This remark is not very fair to Clarke. But then there always have been and always will be improvers of processes which need no improving; the so-called improvements being mere details, thus giving the improvers the opportunity to purloin the honour and merit of the original discoverer. As far as the credit of imagining the process in principle is concerned, the credit is due to Berthollet, who says in his *Art of Dyeing*, "Happily a trivial and easy test is sufficient to show whether a water contains an injurious quantity of these salts (hardness-imparting). This is the solution of soap."—Tr.

soap solution gradually added, testing from time to time to ascertain if a persistent lather be produced. The lather ought to form on the surface of the liquid a regular layer of more than  $\frac{1}{2}$  *centimetre* in thickness and to maintain itself for at least ten minutes without disappearing. The degree read upon the hydrotimeter when this lather has been obtained is the hydrotimetric degree of the water examined. This degree indicates—

1. The number of *decigrammes* of soap which this water neutralises per *litre*.

2. The measure of purity or place which it occupies in the hydrotimetric scale.

For example, if the number 19 be read off, it results that a *litre* of the water tested neutralises 19 *decigrammes* of soap, and that this water bears 19 as its number on the hydrotimetric scale.

The following table gives the hydrotimetric standard of several spring and river waters:—

Kind of Water.	Hydrotimetric Degree.	Quantity of Soap decomposed before a persistent lather is produced in one cubic <i>metre</i> of water. <sup>1</sup>
		<i>Kilogrammes.</i>
Distilled - - - - -	0'0	0
Snow - - - - -	2'5	0'250
Rain - - - - -	3'5	0'350
L'Allier - - - - -	3'5	0'350
La Dordogne - - - - -	4'5	0'450
La Garonne - - - - -	5'0	0'500
La Loire - - - - -	5'5	0'550
La Somme (soda) - - - - -	13'5	1'350
Le Rhône and La Saône - - - - -	15'0	1'500
L'Yonne - - - - -	15'5	1'550
La Seine - - - - -	17'0	1'700
	23'0	2'300
La Marne - - - - -	23'0	2'300
La Dhuis - - - - -	24'0	2'400
L'Escaut - - - - -	24'5	2'450
Belleville - - - - -	128'0	12'800

<sup>1</sup> *Kilogrammes* per cubic *metre* equal lb. per 100 gallons.—Tr.

According to this table it will be seen that if water of 24 hydrotimetrical degrees, for example, be used for soap scouring, 2.4 *kilogrammes* of soap per cubic *metre* of water, say  $2\frac{1}{2}$  lb. per 100 gallons, are required to precipitate the salts in solution, and it is only the soap added over and above this amount that produces any useful effect in soap scouring.

The processes the description of which has just been given suffice in the majority of cases to decide whether a water is more or less pure. Boutron and Boudet have completed their process by applying it to the exact determination of the proportion of carbonate of lime, sulphate of lime and other calcareous salts, salts of magnesia and carbonic acid contained in the water to be analysed. The following, according to them, is the method to pursue. The degree of hardness (hydrotimetric degree) of the water is determined—

1. In the natural state.
2. After precipitation of the lime by ammonium oxalate.
3. After eliminating the carbonic acid and the carbonate of lime by boiling.
4. After precipitating by ammonium oxalate the salts of lime not removed by boiling.

The details of the operations are as follows:—

Knowing the degree of hardness of water in its natural state, to 50 cubic *centimetres* of the water 2 cubic *centimetres* of  $\frac{1}{60}$  solution of ammonium oxalate are added, the whole stirred and allowed to settle for half an hour, after which the water is filtered and thus freed from lime salts. The degree of hardness (hydrotimetric degree) is determined on 40 cubic *centimetres* of this water.

*Example.*—Suppose that 26° of hardness (hydrotimetric degrees) have been got in the first operation in the natural state, and that 9° are found in the second operation. A fresh quantity of the water to be analysed is taken and boiled gently for half an hour to precipitate the lime and expel the carbonic



acid. After cooling, distilled water is added to bring the water back to its original volume; the whole is well mixed and filtered; then the degree of hardness of 40 cubic *centimetres* of the filtered liquid is determined, say, for example, that  $13^{\circ}$  is the figure found. Then to 50 cubic *centimetres* of the previously boiled and filtered liquid 2 cubic *centimetres* of  $\frac{1}{80}$  ammonium oxalate solution are added to expel the lime existing as carbonate which has not been expelled by boiling. After being allowed to stand and then filtered, the hardness is again determined on 40 cubic *centimetres* of the liquid, say, for example, that  $7^{\circ}$  is the figure found. As carbonate of lime is soluble in water, it is not entirely precipitated by boiling in the third operation; it is therefore necessary to correct the degree of hardness obtained after boiling. This correction consists in deducting the constant 3 from that figure, which will give in the present instance  $13^{\circ} - 3^{\circ} = 10^{\circ}$ .

From the readings previously made the following conclusions are drawn :—

The first hydrotimetric degree, read off  $26^{\circ}$ , indicates that carbonic acid, salts of lime (carbonates, etc.) and of magnesia contained in the *litre* of water are neutralised by 26 *decigrammes* of soap.

The second degree, read off  $9^{\circ}$ , indicates the salts of magnesia and carbonic acid remaining in the water after elimination of the lime; therefore  $26^{\circ} - 9^{\circ} = 17^{\circ}$  gives by differences the proportion of the hardness due to salts of lime.

The third figure which, after correction, is  $10^{\circ}$ , represents the salts of magnesia and the salts of lime other than the carbonate; therefore  $26^{\circ} - 10^{\circ} = 16^{\circ}$  gives by difference the proportion of the hardness due to carbonate of lime and carbonic acid.

Finally, the fourth degree,  $7^{\circ}$ , indicates the salts of magnesia which have been left untouched by boiling with

ammonium oxalate. By adding together the degrees of hardness due to salts of lime and magnesia, say  $17^{\circ} + 7^{\circ} = 24^{\circ}$ , it will be seen that in the  $26^{\circ}$  of hardness in the natural water only  $2^{\circ}$  are due to carbonic acid.

The water tested contains, therefore, in hydrotimetric degrees :—

Free carbonic acid	-	-	-	$(26^{\circ} - 24^{\circ}) = 2^{\circ}$
Carbonate of lime	-	-	-	$(16^{\circ} - 3^{\circ}) = 13^{\circ}$
Sulphates of lime and magnesia	-	-	-	$(17^{\circ} - 13^{\circ}) = 4^{\circ}$
Salts of magnesia	-	-	-	$= 7^{\circ}$

The following table gives the equivalent in weight of a hydrotimetric degree for a *litre* of water of a certain number of simple and compound bodies :—

			<i>Grammes per litre.</i>
Lime	1 degree	-	0'0057
Calcium chloride	"	-	0'0114
Calcium carbonate	"	-	0'0103
Calcium sulphate	"	-	0'0140
Magnesia	"	-	0'0042
Magnesium chloride	"	-	0'0090
Magnesium carbonate	"	-	0'0088
Magnesium sulphate	"	-	0'0125
Sodium chloride	"	-	0'0120
Sodium sulphate	"	-	0'0146
Sulphuric acid	"	-	0'0082
Chlorine	"	-	0'0073
Soap, 30 per cent. water	"	-	0'1061
Carbonic acid, free	"	-	0'0050

By this table the weight of the salts found may be calculated from the hydrotimetric degrees yielded by the water tested.

*Example.*—In the preceding analysis the degree of hardness due to carbonic acid was found to be  $2^{\circ}$ ; all that is required to be done is to multiply this number by 0'005 *litre* of the preceding table; thus  $2 \times 0'005 = 0'010$  *litre* of free carbonic acid.

The hardness due to carbonate of lime was  $13^{\circ}$ , which will give in weight  $13 \times 0'0103 = 0'133$  *gramme*.

Hardness due to sulphate of lime  $4 \times 0'0140 = 0'056$ .

Hardness due to sulphate of magnesia,  $7 \times 0.0125 = 0.0875$ .

Owing to the small amount of hardness due to carbonic acid, it will be seen from the foregoing that the hydrotimetric degree of a water represents approximately the weight in *decigrammes* of the earthy salts which it contains.

#### DERVAUX PURIFIER.

This system of purifying consists in mixing—in proportions regulated according to its composition—by means of a distributing apparatus, the water to be purified, arriving by the pipe, with a saturated solution of milk of lime, produced in a saturating apparatus, and if need be with soda or other liquid reagent, and then causing the mixture to traverse a decanting apparatus, from which it issues purified by the tubulure.

*Distributing Apparatus.*—The water to be purified arrives through the valve into the distributing reservoir, from whence it runs into a decanting tank by a pipe, and issues from it by another pipe, traversing first from below upwards a saturator, from whence it issues saturated with lime by the tubulure.

A solution of carbonate of soda is generally required for purification, in addition to a saturated solution of lime water. The necessary quantity of this additional reagent is dissolved in the reservoir. The reservoir feeds, by keeping it at a constant level with a solution of carbonate of soda, a small tank with float, equal in height to the reservoir. A movable outflow tube is attached to the bottom of the reservoir, and is suspended by its free extremity, pierced by an exit orifice calibrated to the float floating on the water of the reservoir. The object of this arrangement is to stop the flow of the soda simultaneously with that of the reservoir. Moreover, the flows from the two tanks under the same charge of water are always in constant ratio.

If another reagent, such as persulphate of iron, requires to be used in the purifier, a second dissolving tank and a second distributing reservoir for distributing this reagent is naturally employed.

*Saturator.*—The object of the saturator is to transform a part of the water to be purified into saturated lime water, and to mix it with the other part to purify it. Clear, saturated lime water contains 1·23 *gramme* of quicklime per *litre*.

The Dervaux Cone Saturator is a vessel with an elongated conical bottom traversed from below upwards by the water to be saturated, which, as it flows in, is carried to the bottom of the saturator by the tube. Each day the charge of lime is run into the hopper, where it slakes in contact with the water, and by stirring it up therewith it is forced down the cone. The bottom of the cone being sufficiently acute, the current of water flowing in by the tube passes from below upwards and keeps the lime in suspension as milk of lime. The milk of lime thus formed rises slower and slower from the acute bottom towards the upper and gradually wider part of the cone, where, owing to the slackening of the speed of ascension, the lime in suspension separates from the water and falls back, and is conducted down the inclined sides to the bottom of the saturator into the water which runs in there by the tube which carries it up again, and so on until thoroughly exhausted. The saturated lime water issues clear from the saturator through the tube, after having circulated through the partitions in the form of inverse cones between which the clarification is effected.

*Decanter.*—The mixture of water to be purified and of saturated lime water is spread over the surface decanter in the reaction chamber, and descends slowly until the reactions have been completed before reaching the decanting surfaces. It results, therefore, that the flocculent precipitate, which forms as soon as the water to be purified and the reagent come

together on the surface of the decanter, traverses the mass of descending water, bringing in its throes the final precipitates formed up to the completion of the reaction. The water afterwards rises slowly between the compartments of the decanter formed by superimposed cones, between which it divides into so many small ascending currents; the matter in suspension is deposited, and clear water reaches the orifice of the collecting pipe of the exit.

If the decantation be not sufficient, the water is made to pass through a filter of wooden shavings, which stops any particles of carbonate of lime which the water may still contain.

#### TESTING THE PURIFIED WATER.

In order to make rapid tests, dropping bottles have been substituted for graduated burettes, and it is presumed that the drops have always the same volume. Instead of counting how many divisions of the burette are run in the number of drops is counted. The orifice of the dropping bottle is such that it requires four drops to make a volume of one-tenth of a cubic centimetre.

*Necessary Apparatus.*—It consists of :—

A dropping bottle. Standard soap solution.

A dropping bottle. Decinormal test acid (acidulated phenolphthalein).

Test bottle graduated from 5 to 20 grammes.

A reagent bottle containing solution of barium chloride, 100 grammes of dry barium chloride to the litre of distilled water.

*Testing the Lime Water.*—Lime water prepared in the following manner is run into the graduated bottle :—

Two or three handfuls of powdered slaked lime, such as would be used for saturation, are run into a litre of water. The lime is mixed in such a manner as to saturate the water with



it ; it is then allowed to settle, and when the liquid is clear the graduated bottle is filled with it to the 5 *gramme* mark. Into the saturated lime water prepared in this way the test acid is poured, drop by drop, from the acidulated phenolphthalein bottle, until a red colouration, at first produced, suddenly disappears. The number of drops is counted. The same result should be produced when the test is made on the lime water of the saturator. The lime water being saturated the decolouration ought always to be produced with the same number of drops. If the decolouration be produced sooner, that would prove that the saturator is in want of lime.

*Testing the Purified Water.*—An hour or so after the lime saturator has been acting properly, the graduated bottle is filled to the 10 *gramme* mark ; there is then run in, drop by drop, the standard soap solution until a light persistent lather is obtained, which must not be confounded with the froth which a bright water gives.

The number of drops, less one, which it is necessary to pour into the water to get this lather represents the hydrotimetric degree of the purified water. Working in good condition this degree ought to range from 4 to 6.

*Testing the Alkalinity of the Water.*—The graduated bottle is filled to the 10 *gramme* mark with the purified water, and one drop of the acidulated phenolphthalein run in from the reagent bottle, fitted with its dropping stopper, and the bottle shaken. The water ought to become slightly reddish, but it ought to be decolourised when a second drop is added.

If the water is not coloured red by one drop there is a deficiency of reagents, and it is then necessary to force slightly both the lime water through the saturator and the quantity of carbonate of soda.

If the water be coloured by the first drop, and be not decolourised by the second drop, it is because there is an excess of alkali in the water, either on account of too much

lime or too much carbonate of soda. In order to see which of the two is in excess, barium chloride is added to the coloured liquid until the 20 *gramme* mark is reached, and the whole shaken. If the liquid be decolourised, carbonate of soda is in excess, because the barium chloride causes the alkaline reaction due to the carbonate of soda to disappear.



The flow of the carbonate of soda must then be diminished.

If the liquid be not decolourised it is on account of an excess of caustic soda or an excess of lime, and in both cases the flow of water towards the saturator must be diminished. It is easy to ascertain which of the two is in excess, lime or soda, according to the degree of hardness of the water, which will be very low if soda be in excess.

By means of these tests water of a sufficient degree of purity is obtained.

*Testing of Water in the Boilers.*—1. The first thing that requires attention is to see that the water fed into the boilers is quite clear. This is verified by running some of the water into a clean clear glass, and observing whether any particles of lime remain in suspension.

2. Water is taken from the gauge glass, and after blowing off for a long time it is collected in a glass, and the test bottle filled with it to the 10 *gramme* mark, then the standard soap solution is added, drop by drop; a lather should not be obtained before the third or fourth drop, otherwise it will be necessary to diminish the quantity of carbonate of soda used in the purification of the water. If it requires more than three drops of soap to make a lather with the boiler water, that shows that the purified water wants carbonate of soda. On the other hand, if 10 *grammes* of the water are run into the test bottle, and chloride of barium added until the 20 *gramme* mark is reached, this water ought to be coloured by one drop of the acidulated phenolphthalein, and ought not

to be decolourised before the sixth or eighth drop, otherwise more lime must be run into the saturator. This last test shows that there ought to be in the water a slight excess of caustic soda.

#### VARIOUS PURIFYING ARRANGEMENTS.

The Dervaux purifier has been described to illustrate the order of ideas in which water purifiers are conceived, and this type has been chosen because the author has seen it work successfully. Various other plans may be conceived. But the process of purifying may be summed up in the mixing of the water to be purified in suitable proportions with reagents which render soluble salts in the water insoluble, and afterwards in separating from the water the precipitates formed.

The decanters have been conceived with the view of dividing the water into thin sheets and causing them to traverse the longest possible road so that they may abandon, in their passage, all suspended matter.

Whatever arrangements may have been adopted for this purpose they are all more or less defective, and no system is superior to that of wide surfaced reservoirs where the water decants slowly.

An arrangement, adopted by Alfred Motte of Roubaix, provides for the mixture of the water to be saturated and the reagents being effected by a Dervaux saturator, and the decantation being effected in vast basins. The quantity of water purified is 2,500 cubic *metres* and upwards daily.

*Filters.*—The decanters are often unable to eliminate the substances suspended in the matter and filters must be resorted to. They are used to clarify the muddy water of rivers, or to retain the precipitates produced by chemical action.

If the volume of water to be filtered is not considerable, filters of charcoal, sponges or shavings may be used. At the end of a certain time the filters are saturated by the substances

which they retain; they become choked and no longer pass water, or, on the other hand, the water in passing through the filter carries with it the deposits left there by other waters in their passage. Frequent cleansings are necessary.

In order to filter large quantities of water it is preferable to adopt an arrangement analogous to that about to be described.

An excavation is made in the ground, 3 *metres* deep, in the form of a truncated cone. The sides are maintained by wooden flooring boards behind which piles are driven in. The whole is rammed all around and a layer of clay is laid in the bottom 0·30 *metre* in thickness to retain the water and separate it from the subsoil water.

The filter bed is made as follows :—

1. A layer of flat stones not joined together, where the water may make a start in depositing. A flush of water will eliminate from time to time the deposits so as to prevent the filter from choking up.

2. A layer of very fine sand of a thickness of 0·50 *metre*.

3. A layer of gravel of thickness of 0·50 *metre*.

4. A bed of small pebbles of thickness 0·15 *metre*.

5. A layer of shingle (stones) of 8 to 10 *centimetres* in diameter of thickness 0·30 *metre*.

6. A layer of bricks pierced with small holes and supported on other bricks laid quincunx fashion so as not to impede the flow of the water towards the centre.

The clarified water falls into an empty space of 0·30 *metre* in height, from which it runs into a central well, from which it is lifted by a pump.

## CHAPTER XVII.

### BLEACHING OF YARN.

WEIGHT OF YARN.—*Numbers of Linen Yarns—Moistened and Dry Yarns—Different Kinds of White—Loss in Weight.*

LYE-BOILING.

CHEMICKING.—*Chemicking of Cotton Yarn—Chemicking of Linen Yarn—Chemicking on Reels—Chemicking on Frames.*

WASHING.—SQUEEZING AND DRYING.

BLEACHING OF COTTON YARN.—CREAMING BY MALACRIDA'S PROCESS.

THE methods about to be described are specially suitable for linen and hemp yarn. They are also applicable to cotton yarns, but as these are easier bleached weaker lyes and chemicks are used and it is not necessary to make the same arrangements for the penetration of the chemicals.

*Numbers of Linen Yarns.*—The packets of yarn have a constant length of 33,000 metres ; it follows, therefore, that the stouter the yarn the heavier is the weight of the packet. The weight of the packet multiplied by the number equals a constant of 540.

For example, a No. 6 packet of yarn weighs  $\frac{540}{6} = 90$  kilogrammes.

A No. 50 packet weighs  $\frac{540}{50} = 10.8$  kilogrammes.

The following table gives the weight of the numbers of the yarns most frequently spun. The weight of the packet is given in kilogrammes and half kilogrammes :—



Number of Yarns.	Weight of Packet.	Number of Yarns.	Weight of Packet.
6	90	32	17
8	68	35	16
10	54	38	14.5
10 $\frac{1}{2}$	50	40	14
14	40	45	12
15	36	50	11
16	34	55	10
18	30	60	9
20	28	65	8.5
22	25	70	8
23	24	75	7.5
26	22	80	7
28	20	90	6
30	18	100	5.5

When the weight of a packet of yarn is too heavy it is made into parcels of half packets or quarter packets. The packet of yarn is divided into 100 skeins.

*Moistened Yarn and Dry Yarn.*—Yarns which are spun before receiving the final torsion pass through a trough containing hot water, where they are de-gummed. These yarns are termed moistened yarn, in contradistinction to those which do not undergo this process and are therefore termed dry yarns.

*Different Classes of White.*—Those yarns which have received one or more lye-boils are termed boiled yarn. They retain their grey colour, but it is brighter.

Those yarns which have been both lye-boiled and chemicked, or simply chemicked, are known as cream yarns. They are of a more or less bright yellow colour. It is but seldom that yarns are completely bleached before being woven.

Yarn bleachers make different kinds of white—quarter white, half white, three-quarters white, white, flower white.

*Loss in Weight.*—The number of the yarn being dependent on the weight of the packet, and the price of the packet increasing with the size of the number, it follows that it is quite to the interest of the yarn merchant that the yarn should lose but as little as possible in bleaching.

On the other hand, no one can expect to bleach yarn without its losing a certain proportion of its weight, because the chemicals used in bleaching render the colouring principles soluble in water and thus facilitate their expulsion.

Yarns bleached under favourable conditions lose between 10 to 20 per cent. of their weight according to the degree of whiteness to which they have been brought in the process. Lyes greatly decrease the weight of yarn. Chemicks, whilst furthering the bleaching process more in the beginning, do not cause so much loss in weight. It must not be lost sight of that it is very difficult to bleach fabrics which have been too energetically chemicked. They are unable to support the vigorous lye-boiling essential to a fine white. The yarn of which the large numbers consist and which is not intended for fine white is "creamed". If they were woven in the state of raw or crude yarn or simply boiled, they would be very difficult to bleach, because the chemicals would not penetrate into the interior of the yarn. Fine fabrics intended to be bleached to a pure white ought to be manufactured from yarn which has been well lye-boiled, but not chemicked. In this way they are able to stand, before being chemicked, the energetic lye-boils indispensable to obtain a fine white.

#### LYE-BOILING.

Sometimes this operation is confined to steeping the yarn in hot water to dissolve gummy substances. The water ought to have at least a temperature of 50° to 60° C., and the yarn must be left there about twelve hours; this water is then run off, and the yarn washed by running cold water on to it.

The keirs used for boiling (*débouillir*) the yarn are analogous to those described for lye-boiling. Wide keirs are to be preferred so as to facilitate the stowing of the skeins.

It is advantageous to provide the keirs with lids, so as to

allow of boiling under pressure, or at any rate to prevent loss of heat. Circulation of the lye is effected by injectors or centrifugal pumps.

The illustration (Fig. 14) shows a keir made by Fontaine of Lille. The lid is raised by a winch which hangs it below

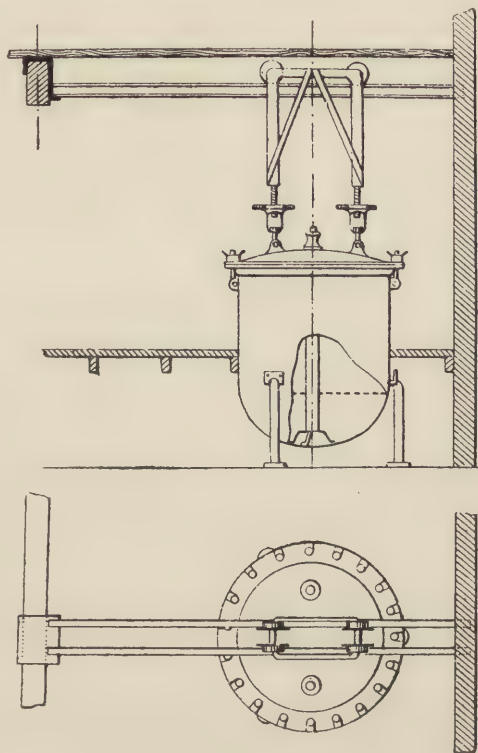


FIG. 14.—Keir for Boiling Yarn.

a waggon running on rails fixed to the ceiling. The lid is removed whilst the keir is being charged and is brought back so as to close the keir during boiling. Circulation is effected by an injector which could easily be replaced by a pump.

The yarns are boiled with carbonate of soda, salt of soda

(i.e., carbonate, with 20 per cent. of caustic soda), or caustic soda. It is difficult to indicate in a general manner the composition of the lyes—that depends upon the end or object which the bleacher has in view. If he wants a fine white he ought to lye-boil strongly; if he desires to preserve the weight he ought to use weak lyes—generally salt of soda lyes of  $1.5^{\circ}$  to  $2^{\circ}$  Baumé is the strength used. Boiling is kept up for six to eight hours.

The yarns must be packed in the keir in such a manner that they are uniformly lye-boiled. The following is a good method of working :—

The lye is prepared in a special tank, then the lukewarm lye is run into the keir, and as fast as it is being run in the hanks are laid into it in such a manner that they are well impregnated with lye and not too tightly packed.

All the hanks being stowed, they are weighted down so as to prevent them from rising out of the liquid. Lye is run in until all the yarn is well covered, the lid is put on, and the temperature gradually brought to  $100^{\circ}\text{C.}$ , or higher.

The yarns may also be packed in the keir in the dry state, weighted down, and the lye run on; then, when the yarns are well impregnated, the lye is circulated and the temperature gradually brought to the boil.

When the boiling is over the lye is run off and then the yarns are washed. If possible, the washing is commenced with hot water, which carries off the substances rendered soluble by the lye better, and the washing is then continued with cold water. In any case it is not good practice to bring the fabrics suddenly from a high temperature to a low temperature, or *vice versâ*, e.g., steeping cold yarn in hot water, or taking them out of that to place them in cold water.

By attending to this observation many annoyances produced by no apparent cause may be obviated.

## CHEMICKING.

Many plans have been proposed for chemicking yarns. They all have the same end in view, *viz.*, the thorough penetration of the liquid throughout the whole of the hanks of yarn.

*Chemicking of Cotton Yarns.*—As they are easily penetrated they may be piled in a tank, pressed down, and the chemick run on to the top of them. Circulation being maintained by the pump, the chemick is brought thoroughly in contact with all the parts of the hanks.

Instead of packing the hanks in the dry state, it is better to run in the chemick as they are being packed in the cistern. They are not squeezed together so much, and a more uniform white is got.

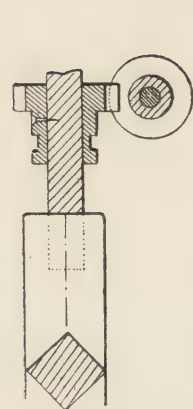
*Chemicking Linen Yarn.*—The preceding method is not suitable for linen yarn, hemp or jute, because the chemick does not penetrate equally throughout every portion of the hanks. Some portions are bleached white, others remain grey.

*Chemicking on Reels.*—By the plant the dimensions of which are shown in Fig. 15 100 kilogrammes of yarn may be creamed at a time. The chemick is contained in a beck built of masonry and lined with cement, 3.45 metres in length, 1.25 metres in width and 0.50 metre in depth (say 11 feet  $\times$  4 feet  $\times$  1 foot 8 inches). It is filled with chemick to the depth of 0.25 to 0.30 metre (say 10 to 12 inches).

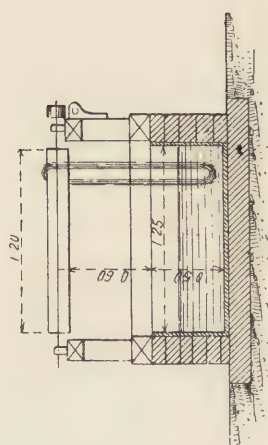
The walls of the beck are surmounted by a wooden framework. This framework supports the reels which carry the hanks of yarn and the shafting which imparts a rotatory motion to them.

The hanks of yarn are hung on square wooden arms or reels 0.10 to 0.12 metre square (4 to 4 $\frac{3}{4}$  inches). The ends of the reels are prolonged by turned iron arms of 0.05 metre





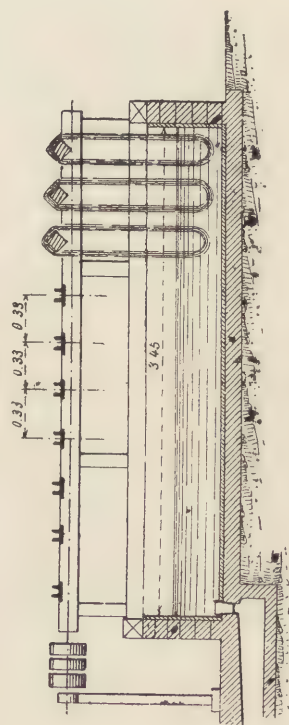
Details of the extremity of a roller.



Cross section.



Plan.



Longitudinal section.

FIG. 15.—Chemicking of Yarn.

(2 inches) diameter. A toothed wheel is fixed to the end of each of these arms. When the reels are charged with yarn they are brought to the chemicking cistern and rest on bearing blocks on each side of the framework. The reels are placed parallel to one another at a distance of 0·33 *metre* (13 inches) from axis to axis.

A driving shaft of 0·035 *metre* ( $1\frac{3}{8}$  inch) diameter, fixed on the side of the framework, carries a series of endless screws which gear into the toothed wheels fixed to the end of the bearing shafts of the reels, and impart to them a slow movement of rotation (five to six turns a minute). The screw shaft is propelled by a belt and pulley. There are three pulleys, one fixed and two free. On one of the two pulleys there is a straight belt, on the other a cross belt. By a suitable gearing arrangement either the straight or the cross belt may be made to bear on the fixed pulley. In this way the motion of the reels may be reversed. Sometimes this is done automatically by an arrangement of levers and counterpoises.

It must be observed that the reels are not fixed into the framework of the chemicking cistern. The hanks are first hung on to them, then two men seize them, each by one end, and bring them into position on the chemicking cistern, and, when the whole are in position, the driving shaft, carrying the bevel wheels which impart the movement of rotation, is started.

Each portion of the hanks is successively exposed to the action of the chemicking liquor and to the air, thus realising the best conditions for the chemick to produce the most energetic effect. The inconvenience is that the yarn gets scraped and deadened on the rollers; it must not, therefore, be reeled for too long a time. An hour to an hour and a half at the maximum is sufficient for one operation. If the yarn bleaches too quickly the chemick will only have a superficial action, for it will not have time to produce a proper effect on the interior

fibres of the yarn. If the yarn bleaches too slowly it is scraped in contact with the reels and becomes frayed.

The following are the strengths of the chemicks that we have employed successfully, using chloride of lime in the cold:—

	Chlorometric Strength in Degrees.
From No. 10 to No. 20	- - 3
„ 20 to No. 35	- - 2
„ 35 to No. 45	- - 1.5
„ 45 upwards	- - 1

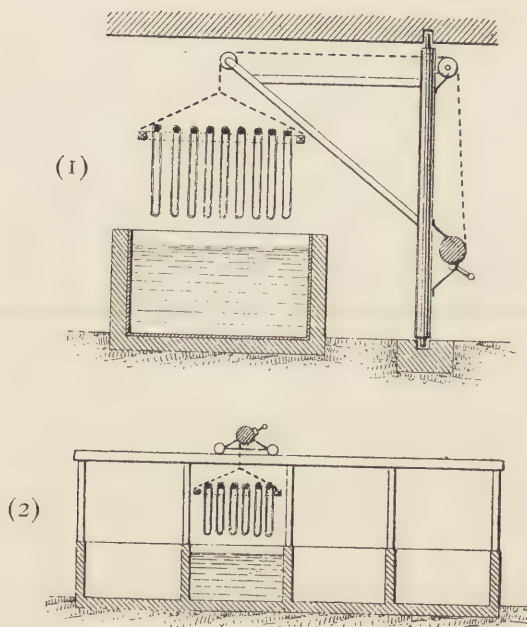


FIG 16.—Chemicking on Frames.

*Chemicking on Frames.*—See Fig. 16 (1). The chemick is contained in a cistern of masonry, or in a wooden vat. The hanks are hung on parallel wooden bars, the ends of which are fixed into a wooden frame.

This frame is hung by a chain which, after passing over two pulleys, is rolled on a windlass. The whole is worked

by a movable crane, by means of which the hanks of yarn may be transported from one cistern to another.

All the hanks being suspended on the frame are brought above the chemicking cisterns by turning the crane, and by means of the windlass are plunged into the liquor. In order to better ensure the contact of the liquid with all the portions of the hanks, a movement of oscillation is given to the whole from above downwards. The hanks may also be taken out of the chemick, exposed some time to the air, and replunged afterwards in the liquor. When the yarn has been steeped the necessary time it is drawn up by the windlass and, turning the crane, it is brought into another cistern containing clean water. When it has been sufficiently washed there, it is again brought by the crane into the scouring cistern, and from there into the washing cistern. Several successive chemicks with intervening sours may thus be given with but little labour. This method of washing by simple steeping is sufficient between the chemick and the sour, but it would not be sufficient for the washing preceding drying, which requires to be done more energetically.

This system is well adapted for fine yarn because it does not fray the yarn as in reeling. It also answers very well for cotton.

Instead of arranging the cisterns in a circle around the crane they can be placed in a straight line (see Fig. 16 (2)). The windlass for manipulating the frame is placed on a bogie the wheels of which run on two small beams of quartering. By moving the bogie the hanks are shifted from one cistern to another.

#### WASHING.

The hanks are washed by hand in water, taking them out and plunging them in eight or ten times.

The machine the general arrangement of which is illustrated

in Fig. 17 is very simple and gives good results.<sup>1</sup> The hanks of yarn are hung on square wooden reels  $0\cdot20$  metre to  $0\cdot25$  metre square. The hanks dip to half their height into a cistern the water of which is being continually renewed. Each machine comprises four or five reels which drive one another by gearing with an arrangement for automatically reversing the

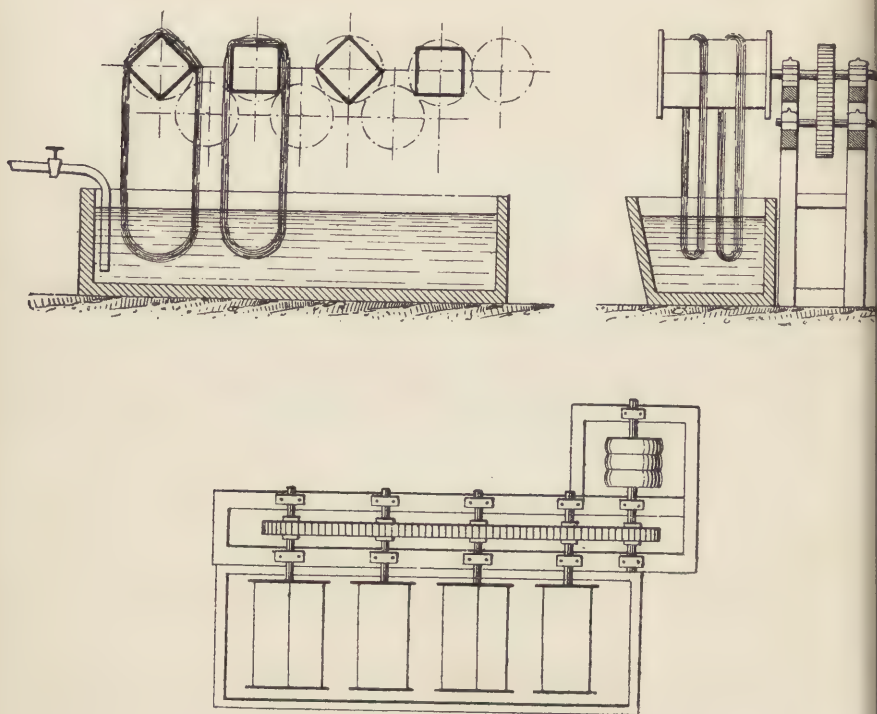


FIG. 17.—Machine for Washing Hanks of Yarn.

rotatory movement periodically. In this way the yarn moves round alternately first in one direction and then in the other.

The reels on which the hanks are hung have one extremity free; the hanks are placed thereon and removed without stopping. The workman whose duty it is strips one reel, hangs on a fresh lot of hanks, passes on to the next, and so on.



Tierce of Rouen makes a machine, the reels of which are arranged in a radial manner to a central shaft and free at the other extremity, and each of these reels revolves with three simultaneous movements. They turn on their own axis, are carried forward by the rotatory movement of the shaft to which they are attached, and finally an oscillatory movement from above downwards is imparted to them which agitates the hanks in the water. This machine, intended for the washing of ribbons, answers very well for washing hanks of yarn.

#### SQUEEZING AND DRYING.

After being washed the yarn is squeezed to express a portion of the water retained by it. This squeezing may either be done by wringing, or by passing them through two compressing rollers, or by means of a centrifugal machine.

Air drying is the best method. The hanks are hung on wooden poles and exposed in hot or cold air drying machines. After six or eight hours linen or hemp yarn should be manipulated whilst still wet. A workman passes a stick through the interior of the hank and gives it several cuts, which separate the threads which have become glued to one another and render them flexible. The yarn is then allowed to dry completely. The dried yarn, so as to render it still more flexible, is sometimes passed through rollers which carry the yarn forward on their rotatory movement.

#### BLEACHING OF COTTON YARN.

In order to obtain a very fine white—

Boil eight hours with salt of soda of 2° Baumé; wash.

Chemick, 0·75° chlorometric strength; steep four hours; wash; sour, sulphuric acid 0·5° Baumé; wash.

Lye-boil eight hours with salt of soda; wash.

Chemick as before.

Sour as before.

Be very careful with the last washing before the blue or before drying. If not white enough give two lye-boils before the first chemick.

#### CREAMING BY MALACRIDA'S PROCESS.

Malacrida of Milan has patented a process for the manufacture of a lye which possesses special properties. Instead of boiling the yarn with full steam for a greater or less length of time it is plunged in the cold in this concentrated lye of 2° Baumé for about two hours. It is then washed and chemicked in the usual way. The advantages of the process are:—

1. Economy of coal, since there is no need for steam.
2. The yarn suffers no loss in weight.

This last point is very important to yarn merchants, for the number of the yarn depends on the weight of the packet. This lye is prepared in the bleach works where it is used, and its price is no higher than salts of soda. This lye has been successfully used for about six years in Ireland, Belgium and Italy.

## CHAPTER XVIII.

### THE INSTALLATION OF A BLEACH WORKS.

*Water Supply—Steam Boilers—Steam Distribution Pipes—Engines—Keirs—Roller Washing Machines, Stocks, Wash Wheels—Chemicking and Souring Cisterns—Various Suggestions—Buildings.*

WHEN a bleach works is to be established the bleacher generally finds that he is controlled in his plans by existing plant, such as buildings, boilers, engines, etc. In such a case he endeavours to profit as far as possible from existing arrangements, and to place the new plant in such a manner as will incur the least expense. More or less costly adaptations are then made, but which, taking everything into account, often cost more in the end than new plant would have done.

It will be supposed that a new bleach works is about to be started, and it is desired to ascertain what is the best arrangement of plant to be made.

All bleaching processes are included in the five following operations. Lye-boiling, chemicking, souring, washing and exposure on the bleaching green. These operations require water, steam, and motive power.

*Water Supply.*—This question is of the greatest importance, because washing plays a vital rôle in bleaching. Water must be available not in large, but in sufficient quantity. A bleach work, should therefore only be established in a district where it is certain that there will never be a dearth of water. The quality of the water must also be taken into account. It

ought to be bright, colourless and not too calcareous. Certain sulphated, ferruginous and ochry waters are altogether unfit for bleaching.

The waters will be drawn from wells, cisterns, or streams, and the particular circumstances of each case will decide the kind of pump to be used. Centrifugal pumps have a good output when they work by return flow, and a bad output when the aspiration depth exceeds  $1\frac{1}{2}$  metre (5 feet). The water should be stored in as large a reservoir as possible and on such an elevated situation as will enable it to be delivered at a suitable pressure into all the machines. The bottom of the reservoir should be raised  $3\frac{1}{2}$  to 4 metres (say  $11\frac{1}{2}$  to 13 feet) above the level of the ground.

The water will be distributed into the different departments by main conduits, and smaller pipes will serve for distributing the water to the machines. Taps placed at convenient spots serve to isolate the different branch pipes in case of repairs or in the nights of winter, when the pipes should be emptied for fear of frost.

For running away the water a large drain is made in the centre of the factory so as to carry off the wash waters, saline lyes, chemicks and sours. This drain should be provided with ventilators and should be large enough to be entered and cleaned. The exit shoot should be at a level high enough for the water to run into the discharge canal and not re-ascend into the drain. All the bottoms of keirs, chemicking and souring cisterns should be high enough for the water to flow to the main drain. All the small branch drains should be placed beneath the passages, so that they may be easily inspected and cleaned.

*Steam Boilers.*—High pressure steam boilers, 8 to 12 atmospheres, answer very well for steam engines with a regular consumption. But to meet the requirements of a bleach works it is better to choose low pressure boilers, 4 to 5

atmospheres, containing a large quantity of water and a great reserve of steam. When a lye is heated there is at first a great consumption of steam to bring it to the boil, after which it requires but a small quantity of steam to keep it at that temperature. Steam is thus taken from the boiler in an irregular manner. If the boiler has not got a great reserve of heating power the pressure will soon fall and the stoker will have to urge his fires so as to get the steam up to the right pressure. He cannot therefore stoke his fires regularly, and will consequently consume much more coal. If the bleach works be on a large enough scale to warrant it, it would be advisable to provide steam boilers for the engines and separate ones for heating the lyes, etc. In many bleach works it is the practice to make the lyes during the night. It saves time, seeing that in the morning the fabrics are ready to be taken out of the keirs to undergo other treatment. Working in this way a greater amount of work can be done with a smaller number of steam boilers. During the day-time they provide steam for the engine and at night for heating the lyes.

Space should be left for laying down boilers alongside those previously existing. The spot reserved for them may be used to store coal or other materials. It is very annoying to have boilers scattered all over the works. It should be easy to get at the boilers. One should be able to get them out for repairs without breaking down great lengths of wall or having to resort to measures of extreme difficulty. The coal store should be near the fires.

The arrangement of flues which lead the smoke to the chimney should be carefully studied. By neglecting this precaution incredibly absurd directions are given to the flues, resulting in a bad draught and annoyance of every description which might easily have been avoided by more serious consideration at the time they were built.

Drying chambers are sometimes built above the boilers



to utilise the heat. The author does not advise this being done. White fabrics cannot be dried therein on account of the coal dust. As to building drying chambers for substances uninjured by dust, by separating them from the top of the boilers by perforated boards, such a structure might lead to a fire on account of the cotton waste, etc., and, in any case, does not conduce to cleanliness, an object already difficult enough to attain.

It is evident that the boilers should be near to the engines and the keirs.

*Steam Distribution Pipes.*—Copper steam pipes suit the best, but they are too costly. Iron pipes are still used. There is danger of the steam carrying rust along with it.

The firm of Sergot, of Paris, makes iron pipes galvanised inside to prevent rust.

It is not advisable to use cast-iron pipes for steam. Cast iron is brittle, and if a pipe burst the pieces fly about. Wrought-iron or copper pipes are simply wrenched asunder.

Two or three main steam pipes should be laid on furnished with unions from which smaller pipes are led to the different machines. Steam valves are fixed at the commencement of the principal pipes. The steam can thus be shut off in all the pipes when the work is finished, or when a joint starts leaking. The steam pipes should, especially the larger ones, be covered with a non-conducting composition. Simple coils of straw or reeds produce a very good effect.

At different intervals syphons with taps are placed for running away the condensed water, and the slope of the pipes should be towards these taps.

*Engines.*—The steam engine should be placed in a central position, and the transmitting shafts should radiate from it in different directions. The machines requiring the greatest amount of force, such as the stocks and the wash wheels, are placed near the engine.

If the circulation of the lye in the keirs be effected by a centrifugal pump, it is advisable to have a small special motor to drive it, so that the circulation of the lye is not interrupted during the stoppage of the engine. When lye-boiling is done in the night-time a small motor becomes necessary, because the principal engine and all the transmission shafting cannot be kept going to drive two or three pumps.

It is advantageous to have transmission shafts which revolve very quickly, and to reduce the speed by gearing and pulleys so as to impart a suitable speed to each machine. This permits of installing light shafting, etc.

*Keirs.*—The lye-boiling keirs should be located near the steam boilers. They should be placed in line; behind them should be the cisterns for preparing and revivifying the lye. There should be two classes of keirs, one for lye-boiling at a high temperature, the other for dilute lyes, which are generally boiled at the atmospheric pressure.

*Roller Washing Machines, Stocks, Wash Wheels.*—A large passage should be left between the keirs and the washing machines. The first row of washing machines should be placed in front of the keirs. These washing machines will draw the fabrics from the keirs without any necessity for intervening manipulation. Another row of washing machines should be placed between the chemicking cisterns and the souring cisterns. The fabrics which have been chemicked are drawn from the chemicking cisterns by the roller washing machines, washed and delivered through a reel into the souring cisterns. In front and behind each washing machine sufficient space is left for the passing of trucks, and for the laying down of movable wooden boards, on which the fabrics, which are not to be immediately chemicked or soured, are piled. It is advisable to place small squeezers alongside the washing machines to free the fabrics from water. In those cases where only a single row of roller washing machines is to be laid down, they should be located

between the chemicking cisterns and the souring cisterns. The fabrics coming from the keirs can be washed by passing them over and above the chemicking cisterns, supporting them through the intervening space by reels.

The stocks, wash wheels, squeezers (centrifugal machines) may be placed further away from the keirs, chemicking and souring cisterns, as the fabrics do not pass directly from the one to the other. As these machines require a deal of motor power they are placed near to the steam engine.

*Chemicking and Souring Cisterns.*—The chemicking cisterns are constructed preferably of mason work and lined with cement. They are placed in a row and are in communication with a pump so that the lye may be passed from the one cistern to the other. A certain number of the cisterns are surmounted by rollers for reeling the fabrics—that is to cause them to pass from one side of the cistern to the other. Near by are placed the cisterns and plant for dissolving the chloride of lime. This workshop should be separated at least by a partition from the rest of the bleach works, on account of the dust from the chloride of lime; which is very injurious to the health of the workmen, and which, falling on the fabrics, would lead to serious damage.

The souring tanks are made of wood; they are placed in a row and communicate with a pump, or better still with a Koerting injector, so that the acid may be run from one basin into another.

*Various Suggestions.*—The best sites in the author's opinion for the principal plant used in bleaching have now been indicated. Room must however be reserved for the soap scouring and rubbing machines, stretching machines, etc. Different places will be chosen for storing the fabrics. The place where the fabrics are assorted and the progress of the bleaching process ascertained ought to be lighted from the north or the east.

Finally, there ought to be special warehouses for receiving unbleached fabrics and establishing their identity, as well as warehouses for storing the bleached fabrics waiting for despatch. It is also necessary to provide warehouses for storing alkali, bleaching powder, acids, and different mercantile stores.

We need not revert to the laying out of the bleaching green, having dealt with this question in the chapter devoted to exposure on the green.

*Buildings.*—These should be constructed in such a manner as to resist moisture and both alkaline and acid vapours. The use of iron should be avoided, because the rust which is detached from it falls on the fabrics and can only be removed with great difficulty without causing holes. The articles or pieces which it is necessary to have made of iron should always be painted. As far as possible there should be no overhead buildings or second storey above the bleaching rooms; that would lead to difficulty in lighting the workshops, as well as in ventilation. The air is constantly charged with moisture which disintegrates the walls.

The workshops are covered with double-sloped roofs, and lighted from the north or east. Below the rafters a ceiling of cement is made, which is almost unattackable by moisture. Any coating below the roofing would not give sufficient protection against cold, and outside dust might be introduced between the tiles or the slates. The beams are supported by cast-iron columns. These columns are arranged so as to receive the bearings which carry the shafting. They should be 4 to  $4\frac{1}{2}$  metres in height, so that the shafting may be raised above the ground, and so that no one is hindered by pulleys or windlasses. Draught chimneys, with ventilators, are arranged along the roofs so as to carry off the clouds of condensed steam.

Asphalt constitutes the best paving; it is even preferable

to cement, which costs much more. It is very convenient to transport the fabrics into the bleach works or on to the bleaching green inside trucks running on rails. Tram lines should be laid down to bring the trucks to the places where the fabrics are the most frequently handled.



## CHAPTER XIX.

### ADDENDA.

#### ENERGY OF DECOLOURISING CHLORIDES AND BLEACHING BY ELECTRICITY AND OZONE.

ENERGY OF DECOLOURISING CHLORIDES.—*Bleaching Action of Chlorides—Chlorine Water—Alkaline Hypochlorites—Remark on the Method of Estimating Chlorine—Rapidity of Action of the Bleaching Energy of Chlorides—Hypothesis as to the Composition of Decolourising Chlorides.*

PRODUCTION OF CHLORINE AND HYPOCHLORITES BY ELECTROLYSIS.—*Theoretical Data connected with the Decomposition of Sodium Chloride by Electrolysis—Causes of Loss in Yield—Plant for producing Hypochlorites by Electrolysis—Hermite's Plant—Brochoki's Apparatus—Leclanché's Apparatus.*

LUNGE'S PROCESS *for Increasing the Intensity of the Bleaching Power of Chloride of Lime.*

TAILFER'S PROCESS *for Removing the Excess of Lime or Soda from Decolourising Chlorides.*

#### BLEACHING BY OZONE.

#### ENERGY OF DECOLOURISING CHLORIDES AND BLEACHING BY ELECTRICITY.

THESE two questions require to be treated consecutively. In fact, speaking correctly, we do not bleach by electricity, because this process of bleaching would consist in causing an electric

current to traverse the substances to be bleached, which would transform the colouring principles into colourless substances, or at any rate render these coloured bodies soluble in water, so that they might be easily expelled by washing. Now the author does not believe that such a result has ever been obtained, or even that any attempts have been made to work out this line of ideas.

As a matter of fact bleaching by electricity consists in producing decolourising chlorides by electrolysis, and this method of bleaching is distinguished from others by the special properties which the chlorides thus obtained possess.

By first studying the force of energy of the decolourising chlorides we shall see to what the rapidity of their action is due, and then in the sequel why the decolourising chlorides obtained by electrolysis are more energetic than those obtained by chemical means.

#### ENERGY OF DECOLOURISING CHLORIDES.

*Bleaching Action of Chlorides.*—It is acknowledged that this action is due to the oxidising power of chlorine. It produces—

1. An immediate decolouration of the textile fibre in consequence of the oxidation of the heterogeneous substances already prepared by several lye-boilings to be acted on by oxygen.

2. A partial oxidation of the colouring matter, which renders it soluble in alkalis. The colouring principle, which is regarded as an acid itself, produces the decomposition of the chloride of lime; for example it forms with it—

- (a) Insoluble pectates, which render the first chemicks and the first washings milky.

- (b) Soluble metapectates, which are carried away in the wash water.

- (c) A disengagement of free chlorine, which acts as a decolourising agent and transforms the pectates into metapectates

The fabrics which come out of a bath of chloride of lime (chemick) contain a lime soap (pectate of lime). If this pectate of lime be not decomposed by an acid bath (sour) and the fabrics in this condition lye-boiled, the stability of this lime soap will be increased and the result will be negative.

Hypochlorite of soda does not present the same disadvantage, because the salts which it forms with colouring principles are more soluble.

*Chlorine Water.*—It would seem therefore, according to the above, that there would be an advantage, from a bleaching point of view, in the use of gaseous chlorine dissolved in water in place of hypochlorites. There are several disadvantages in working in that way.

Chlorine gas is but slightly soluble in water and its solution would not stand the cost of carriage.

Under the influence of heat and light, chlorine decomposes water and forms hydrochloric acid.

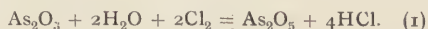
It would therefore be necessary to make the chlorine in the bleach works and to make the solution of chlorine as required. This was how they worked in bleach works when they first commenced to use chlorine as a bleaching agent, but this method was given up when the hypochlorites were discovered.

Finally, bleaching with chlorine water injures the fabric, because this chlorine passes to the state of hydrochloric acid, which, finding no further base to neutralise, acts in a destructive manner on the fibre.

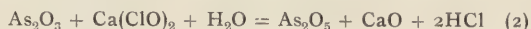
*Alkaline Hypochlorites.*—The alkaline bases have the property of absorbing chlorine and forming with it very unstable combinations, the composition of which is not at all well known, and which are known under the names of chlorides or hypochlorites. It requires an excess of base to maintain the stability of these combinations. From that fact alone the base in excess opposes the oxidising or bleaching action of

the chlorine, because it hinders it from being disengaged from its combination, and the desideratum is to provide almost neutral decolourising chlorides for bleaching purposes, that is to say, those which contain but the least possible excess of base. The hypochlorites offer this advantage over chlorine water, that the hydrochloric acid which is formed is soon neutralised by the base of the hypochlorite.

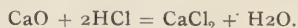
*Remark on the Method of Estimating Chlorine.*—The method of estimating chlorine due to Gay-Lussac is based on the following reaction :—



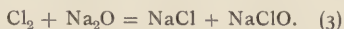
That is to say, two molecules of chlorine transform one equivalent of arsenious acid into arsenic acid. This formula cannot be established otherwise if it be a question of chlorine water, but if hypochlorites of the form  $\text{Ca}_2\text{ClO}$  are being estimated the reaction can also be explained as follows :—



and as secondary reaction :—



This is how we have been led to make this supposition. When chlorine is passed into soda the text-books of chemistry indicate the following reaction as the result :—

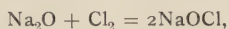


If the hypochlorite thus formed be estimated with arsenious acid almost all the chlorine absorbed by the soda is found as hypochlorite. Now, according to the formula, only half that quantity ought to be so found when titrated with arsenious acid, because chlorine in the state of chloride of sodium does not oxidise arsenious acid. To explain, therefore, how the whole of the chlorine is found as hypochlorite there is occasion to suppose that something analogous to what is indicated in formula (2) takes place.

It has been said that almost the whole of the chlorine

is found as hypochlorite, because there is always a small quantity which passes to the state of chlorate or chloride.

Chemists are not agreed as to the nature of the compounds formed by the combination of chlorine with the alkalis. Kolb assigns a combination which would have the formula  $\text{NaOCl}$ , and it is this latter opinion which appears to be the most capable of explaining the different phenomena observed in connection with decolourising chlorides. According to this hypothesis the reaction of chlorine upon soda would be expressed by the following equation :—



and the reaction with arsenious acid would be :—



*Rapidity of Action of the Bleaching Energy of Chlorides.*—

The point which interests the bleacher is to know to what the greater or less activity of a decolourising chloride is to be attributed. Now there would appear to the author to be no doubt but that it depends on the greater or less excess of base present in the hypochlorite.

When chlorine is estimated by arsenious acid, hydrochloric acid is always added to neutralise the excess of base and to disengage the chlorine from its combination. Let us take several samples of the same hypochlorite and render the first slightly acid, the second neutral, the third alkaline, and gradually increase the alkalinity of the samples.

If we titrate them with arsenious acid without the addition of hydrochloric acid, it will be seen that the chlorometric strength goes on diminishing in proportion as the alkalinity increases. This proves that alkali in excess diminishes the oxidising power of the hypochlorite. On the other hand, if we preserve the samples it will be seen that those which were acid or neutral decompose very quickly, and that the others keep longer without decomposing the greater quantity of alkali in excess which they contain. It follows, therefore, in making



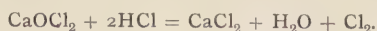
hypochlorites that they should contain the excess of base necessary to preserve their stability, but no more, as that would retard their bleaching action.

*Hypothesis as to the Composition of Decolourising Chlorides.*—

Take the case of chloride of lime for example. The common opinion is that this is a body the formula of which would be  $\text{Cl-Ca-O-Cl}$ . Kolb gave it the formula  $\text{CaOCl}_2$ , and in connection with titration with arsenious acid reasons are given why this explanation would appear to be the most satisfactory. The author believes it necessary to consider chloride of lime as a body in which the following substances may be present :—

1. Chlorine loosely combined with lime. Chlorine A.
2. Chlorine in the free state, which would be simply absorbed or dissolved by the lime. Chlorine B.
3. Chlorine combined with lime in such a stable manner that it has no decolourising power whatever, such as calcium chloride,  $\text{CaCl}_2$ , or chlorates. Chlorine C.
4. Lime in excess amounting to about 35 per cent. in solid chlorides, and in liquid chlorides a quantity of lime corresponding to its co-efficient of solubility in hypochlorites.

This explains the slow decomposition of chloride of lime. In fact, free chlorine in presence of water, heat and light decomposes water, and transforms it into hydrochloric acid. This hydrochloric acid, in its turn, acts on hypochlorite of lime, and sets a fresh quantity of chlorine at liberty.



This free chlorine re-transforms itself into hydrochloric acid, decomposes a fresh quantity of chloride of lime, and so on.

Once the decomposition of the chloride has got a fair start it goes on very rapidly.

That explains why an excess of lime is required to give stability to the chloride. In fact, suppose a chloride where there are present  $\text{CaOCl}_2 + \text{Cl}_2 + \text{CaO}$ . When a small

quantity of free chlorine begins to decompose water to form hydrochloric acid, setting oxygen at liberty, the acid in part attacks the free lime to form calcium chloride and leaves the chloride of lime intact. As the decomposition of the chloride corresponds to a certain quantity of oxygen set at liberty, it will be understood that this bleaching power is abated when the chloride decomposes more slowly.

Trade bleachers have often told the author that a chloride of lime chemick bleached much better after it had served several times than a fresh chemick of the same chlorometric strength. The preceding explanation furnishes the reason for this fact. In reality, the chloride in oxidising the colouring principles transforms them into pectic acid, and this pectic acid neutralises the lime in excess with formation and precipitation of pectate of lime. The alkalinity of the chlorine of lime chemick is thus diminished, and the chloride is more easily decomposed under the influence of the colouring principle, which is acid.

The bleaching power of chloride of lime is generally much more energetic than chloride of soda on account of the slight solubility of lime in water, whilst soda—the solubility of which is very great—is nearly always present in considerable excess in the chlorides of soda of commerce. Hypochlorite of magnesia has a bleaching power still more energetic than chloride of lime.

#### PRODUCTION OF CHLORINE AND HYPOCHLORITES BY ELECTROLYSIS.

When an electric current is made to traverse a solution of chloride of sodium, this chloride is decomposed. The chlorine goes to the positive pole, the sodium to the negative pole. The sodium in presence of water decomposes, forms sodic hydrate with disengagement of hydrogen. Simultaneously with the decomposition of the chloride of sodium there is

decomposition of water, oxygen goes to the positive pole, hydrogen to the negative pole, and, finally, at the positive pole there is formation of chlorine and oxygen, and at the negative pole formation of caustic soda and hydrogen. As soon as these bodies are generated they react one upon another in the nascent state, and the chlorine unites with the soda to form hypochlorite of soda. The rôle which the oxygen plays is not well understood; it perhaps unites with the chlorine to form hypochlorous acid. The hydrogen is in most part disengaged as such; another portion acts upon the hypochlorous acid, reducing it to hydrochloric acid with the final formation of sodium chloride. It thus militates against the end in view, *viz.*, the formation of hypochlorite of soda.

Different schemes and plans have been proposed for producing by this means chlorine, soda, and their compound hypochlorite of soda. In the first place it will be better to give some idea of the phenomena which accompany the electrolysis of sodium chloride.

*Theoretical Data connected with the Decomposition of Sodium Chloride by Electrolysis.*—The electromotive force required to decompose chloride of sodium is 4.2 volts, and under this tension an ampère disengages in one hour 1.331 gramme of chlorine or 0.420 litre of gaseous chlorine. On the other hand, a horse power of 75 kilogrammetres = 736 watts. As the watts equal the product of the volts by the ampères, the number of ampères which give 736 watts under a tension of 4.2 volts may be easily found. This number is equal to  $\frac{736}{4.2}$  = 175 ampères, which disengage in an hour  $175 \times 1.331$  gramme = 232.92 grammes of chlorine or  $175 \times 0.420$  litre = 73.5 litres of chlorine. Therefore, theoretically, in the decomposition of chloride of sodium it requires one horse power to liberate in an hour 232.92 grammes of chlorine or 73.5 litres of gaseous chlorine.

*Causes of Loss in Yield.*—In practice this result cannot be attained, for the following reasons :—

1. The mechanical power cannot be converted into electro-motive force without a loss which varies from 5 to 20 per cent. according to the dynamo. A good dynamo generally furnishes in electrical work 0·83 of the mechanical force which it receives. Adopting this co-efficient, a horse power gives 736 watts  $\times 0\cdot83 = 610$  watts.

2. The cable which transmits the electric current to the electrolyser presents a certain resistance to the passage of the current and absorbs a certain amount of force. It is advisable therefore to use a massive cable so as to reduce this loss of force as far as possible.

*Example.*—Supposing that one was working with a cable of 50 metres intended to transmit a current 100 volts, 100 ampères, and that it was desired to limit the loss of electro-motive force to 3 volts. According to the formula  $E = RI$ , in which E represents the tension in volts, R the resistance in ohms and I the intensity in ampères, we get

$$3 = R \times 100 \quad R = \frac{3}{100} = 0\cdot03 \text{ ohm.}$$

Now, the resistance of a brass wire 1 metre in length of a section of 1 square millimetre is 0·016 ohm. The section S of a conductor of 50 metres in length and offering 0·03 ohm resistance will be in square millimetres—

$$S = \frac{50 \times 0\cdot016}{0\cdot03} = \frac{0\cdot8}{0\cdot03} = 27 \text{ square millimetres.}$$

About 3·5 ampères are passed per square millimetre of section. It is necessary to choose a cable massive enough for the loss of electromotive force due to the resistance not to exceed 5 per cent. of the total voltage to be transmitted.

3. An electric current in traversing a saline solution to be electrolysed suffers a resistance which heats the solution, and a portion of the work of the electric current is converted into

heat. It is advantageous to diminish this resistance, and it is done by bringing the electrodes as near to each other as possible, and concentrating the salt liquor to the point which corresponds with its maximum degree of conductivity. A solution of sodium chloride attains this maximum point when it has a density of  $24^{\circ}$  B. The conductivity of copper being represented by 100,000,000, the conductivity of the salt solution is then about 40. Its conductivity compared with that of copper is therefore

$$\frac{40}{100,000,000} = \frac{1}{2,500,000}.$$

*Example.*—Suppose that the electrodes are at a distance of  $l = 0.10$  metre, that the section of the salt liquor which separates the two is 2,000 square centimetres and that the current has a force of 100 ampères. It is required to find what is the theoretical loss of voltage due to the resistance of the salt solution. This loss of voltage is given by the formula  $E = RI$ . It is required to find what is the resistance in ohms of the salt solution.

A copper wire 1 square centimetre in section, or 100 square millimetres, and 1 metre in length offers a resistance of 0.00016 ohm; therefore the resistance of the solution, the conductivity of which is  $\frac{1}{2,500,000}$  compared with copper, the section  $S = 2,000$  square centimetres and the length  $l = 0.10$  metre will be

$$R = \frac{2,500,000 \times 0.10 \times 0.00016}{2,000} = 0.02 \text{ ohm.}$$

By bringing this value  $R$  into the formula  $E = RI$  we get

$$E = 0.02 \times 100 = 2 \text{ volts.}$$

The loss of voltage due to the resistance of the solution is in this case 2 volts.

To find what will be the heat of the salt solution we have

$$C = \frac{RI^2}{g \times 424};$$

$C$  being the number of calories, 424 kilogrammetres the



mechanical equivalent of one calorie, and  $g = 9.81$  the acceleration of gravity.

Therefore, in the present instance,

$$C = \frac{0.02 \times 100^2}{9.81 \times 424} = 0.05$$

or 0.05 calories per second, and per hour  $3,600 \times 0.05 = 180$  calories. If there be 30 *litres* of liquid in the vessel, the elevation of temperature will be 6° C. per hour.

4. The electric current, at the same time that it decomposes the chloride of sodium, also decomposes the water, which only requires 1.5 volts of electromotive force for its decomposition. The law according to which the relative proportions of water and chloride of sodium are determined is not known; it depends on the surface of the electrodes, their distance apart, and perhaps also on the total voltage, and the degree of concentration of the salt solution.

5. The chlorine, which is disengaged at the positive pole, cannot entirely be collected in the form of hypochlorite of soda. Caustic soda, oxygen and hydrogen are also produced. The hydrogen has a tendency to unite with the chlorine to form hydrochloric acid, and this hydrochloric acid in the presence of soda yields sodium chloride and water. If the temperature of the liquid exceeds 32° to 35° C., the hypochlorite of soda partially decomposes, yielding chlorate.

*Plant for producing Hypochlorites by Electrolysis.*—There are two kinds. In the first, the hypochlorite is produced in contact with the electrodes; in the second, the chlorine and the soda are prevented from combining in the electrolyser, and are combined afterwards in another apparatus to form hypochlorite.

*Hermite's Plant.*—See illustration, Fig. 18. It consists of a galvanised iron tank, in the bottom of which is a pipe pierced with small holes, through which the solution arrives. This solution, partly converted into hypochlorite, runs out by

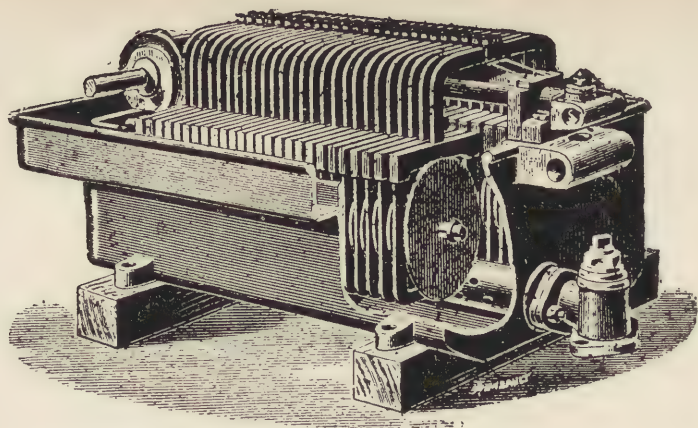


FIG. 18.—Hermite's Electrolyser.

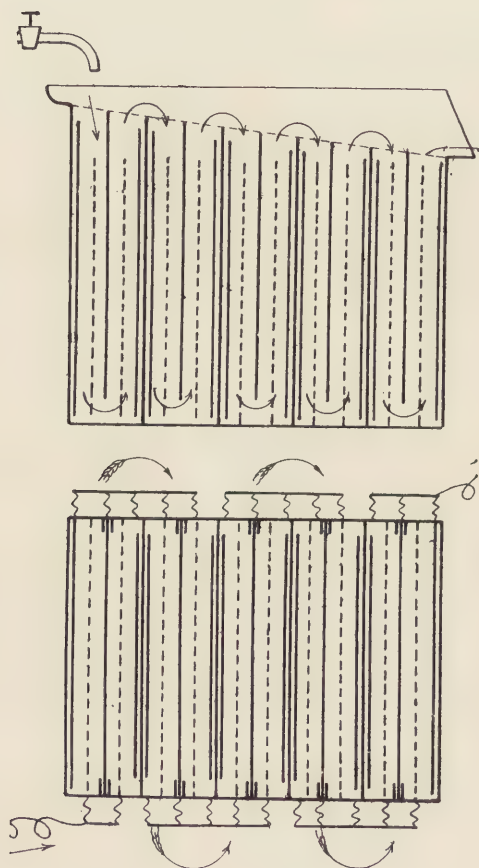


FIG. 19.—Brochoki's Electrolyser.

the rimmed edges of the tank, which serve as exit channels. The cathodes are formed of zinc discs mounted on an axis which revolves slowly. The anodes of platinum foil are intercalated between each cathode. The platinum foils are kept rigid by ebonite frames and are soldered in their upper part to sheets of lead. The sheets of lead bind them to a bar of copper, through which the current comes. In this way all the sheets of platinum are connected on the surface, and the same is the case with the zinc discs, which are connected together by their axes.

The sheets of zinc as they turn rub against a flexible sheet of ebonite and are thus kept constantly clean.

Hermite gives the following particulars regarding his apparatus :—

He uses chloride of magnesium in preference to chloride of sodium, because it requires less electromotive force to decompose it, and because hypochlorite of magnesia of equal chlorometric strength has a more rapid and superior bleaching power than chloride of lime. Owing to the high price of chloride of magnesium he uses a solution of a mixture of magnesium and sodium chlorides. Magnesium chloride is transformed into hypochlorite, and the chloride of sodium serves to render the solution more conductible. The following are the proportions :—

	Parts.
Water - - - - -	1,000
Sodium chloride - - - - -	50
Magnesium chloride - - - - -	5

The flow is regulated in such a manner that the solution attains a suitable degree of strength, and it is propelled into the chemicking cistern, where the bleaching is effected. The operation finished, the liquid is propelled by a pump into an upper tank, whence it returns to the apparatus to be again electrolysed.

According to Hermite the following reactions occur in

the process of bleaching. The oxygen acts on the colouring principles, which it oxidises with formation of carbonic acid; the chlorine produces hydrochloric acid, which, in presence of magnesia, combines with it to re-form the original magnesium chloride. The same chloride of magnesia can thus serve indefinitely. The only loss is in the quantity of saline solution retained by the fabrics being bleached.

Hermite states that with his apparatus a motive force of 10-horse power can produce in twenty-four hours the equivalent of 100 *kilogrammes* of chloride of lime at the following cost:—

1.—Works with Hydraulic Power.

	Francs.
(1) 10 Hydraulic horse power, nominal.	
(2) 30 <i>kilos.</i> common salt at 0.05 franc per <i>kilo.</i> - - -	1.50
(3) 6 <i>kilos.</i> magnesium chloride at 0.12 franc per <i>kilo.</i> - - -	0.72
(4) Depreciation of electrical plant - - - - -	3.00
	<hr/>
	5.22
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2.—Works with Steam Power.

	Francs.
(1) 10-Horse power for 24 hours, 240 <i>kilos.</i> of coal at 20 francs the ton - - - - -	4.80
(2) Common salt, 30 <i>kilos.</i> at 0.05 franc the <i>kilo.</i> - - -	1.50
(3) Magnesium chloride, 6 <i>kilos</i> at 0.12 franc the <i>kilo.</i> - - -	0.72
(4) Depreciation of electrical plant - - - - -	3.00
	<hr/>
	10.02
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To this must be added the cost of superintending the working of the apparatus. If the apparatus be small the workman can attend to something else at the same time. It is well to observe that it is not the 6 *kilogrammes* of chloride of magnesia which produce the equivalent of 100 *kilogrammes* of chloride of lime. These 6 *kilogrammes* of chloride of magnesia as well as the 30 *kilogrammes* of chloride of sodium are intended to replace the salts which have been retained by the fabrics to be bleached, but it is the chloride of magnesium produced by the decomposition of the hypochlorite of magnesium during the bleaching which is electrolysed afresh, and that indefinitely.

*Yield of Hermite's Apparatus.*—On the supposition that the dynamo gives a return of 90 per cent., 10-horse power will give

$$10 \times 0.90 \times 736 \text{ watts} = 6,624 \text{ watts.}$$

The electromotive force absorbed by a cistern being 5 volts, the number of ampères will be  $\frac{6,624}{5} = 1,325$  ampères, and as an ampère liberates during one hour 0.420 *litre* of chlorine, in twenty-four hours there would be produced

$$24 \times 1,325 \text{ A} \times 0.420 \text{ litres} = 13,356 \text{ litres of chlorine.}$$

100 *kilogrammes* of chloride of lime containing the equivalent of 10,000 *litres* of chlorine, the yield of Hermite's apparatus would be in this case

$$\frac{10,000}{13,356} = 0.72 \text{ or } 72 \text{ per cent.}$$

*Brochoki's Apparatus.*—The general plan of this apparatus is illustrated in Fig. 19. It consists of an ebonite case divided into five compartments. In each compartment there are three sheets of lead, and two sheets of platinum are intercalated between the sheets of lead. The platinum foil is kept rigid by an ebonite frame, and is soldered in its upper part to a copper rod. The sheet of lead in the middle connects with a gutter, and leaves an empty space between its lower edge and the bottom of the case.

*Direction of the Current.*—The illustration shows how the leads and the platins are joined. In each compartment the two sheets of platinum are joined together on the surface as well as the three sheets of lead, and from one compartment to another the connection is made in tension.

The current arrives at the platinum of the first compartment, traverses the salt solution, electrolyses it, and goes on to the leads. These leads are connected with the two platins of the next compartment. This compartment acts like the first, and so on. The difference of potential for each compartment is 5 volts; it requires, therefore, for a vat of



five compartments an electromotive force of 25 volts. The surface of the electrodes have been calculated to allow the passage of a current of 100 ampères, using a salt solution of 6° Baumé.

The sheets of lead have a useful surface of  $4 \times 0.30 \text{ metre} \times 0.30 \text{ metre} = 0.36 \text{ square metre}$ .

The platinum sheet has a surface of  $0.36 \text{ metre} \times 0.28 \text{ metre} = 0.10 \text{ square metre}$ , and as the two surfaces act in each sheet, and as there are two sheets in each compartment, the total surface is  $4 \times 0.10 \text{ square metre} = 0.40 \text{ square metre}$ .

It will be seen, according to this, that a current of  $\frac{100}{36} = 3$  ampères is passed per square *decimetre*. The distance between the sheets of lead and the platinum ones is 2 *centimetres*.

*Course of the Salt Solution.*—The salt solution is poured into the first part of the first compartment ; it descends, passes under the sheet of lead, re-ascends into the second part of the first compartment ; it diverts into the second compartment, where it circulates in the same way as in the first, and so on. The tops of the ebonite compartments of the vat, all sloping downwards, or diminishing in height towards the exit, the saline solution runs out at the lower extremity of the vessel, after having been gradually enriched in hypochlorite of soda in contact with the electrodes.

The author has made numerous experiments with Brocho-ki's apparatus, which yielded to him the following results :—

1. The hypochlorite of soda obtained is a neutral liquid, which is a very energetic bleaching agent. This liquid, of 1.25 chlorometric degree, can cream yarn in forty minutes, which takes sixty to eighty minutes to cream with chloride of lime of 2 chlorometric degrees.

2. The chlorometric strength obtained is always low ; 1.5 to 2 chlorometric degrees would appear to be the maximum, and in the course of working it rarely exceeds 1 chlorometric

degree. It is necessary that the outflow be rapid enough to prevent elevation of temperature. If the temperature exceed  $32^{\circ}$  to  $35^{\circ}$  C., a portion of the hypochlorite is converted into chlorate.

3. This liquid, by the very fact that it is an energetic bleaching agent, is very unstable. From night till morning its strength lowers from  $1.5^{\circ}$  to  $0.75^{\circ}$  chlorometric strength ; it then continues to decompose more slowly. It is rendered more stable by the addition of a little soda.

4. It follows, from the feeble strength of the hypochlorite, that it entails reservoirs of considerable dimensions for storing it.

5. When the surface of the leads is clean a solution of  $6^{\circ}$  Baumé is of sufficient conductivity, but this surface oxidises and resists the passage of the current. So as not to be under the necessity of increasing the voltage, the solution must be rendered a better conductor by concentrating it to  $20^{\circ}$  to  $24^{\circ}$  Baumé.

6. In the experiments undertaken by the author, he endeavoured to re-electrolyse the salt solution after having used it for bleaching purposes, but he found that the yield by the second re-electrolysis was very bad ; it did not exceed 10 to 15 per cent. of the theoretical yield.

7. Under these circumstances, the expense in common salt becomes very considerable, because if hypochlorite of  $1^{\circ}$  chlorometric strength be produced, and if there be employed for the purpose a solution of  $20^{\circ}$  Baumé, say containing 200 grammes per litre, there will be 10 grammes of salt transformed into hypochlorite and 190 grammes lost, say 5 per cent. of salt utilised and 95 per cent. lost.

*Remark.*—The use of platinum electrodes renders the cost of the plant very high. Platinum always preserves its value, and, as far as it is concerned, there is nothing to be considered but the interest of the invested capital.

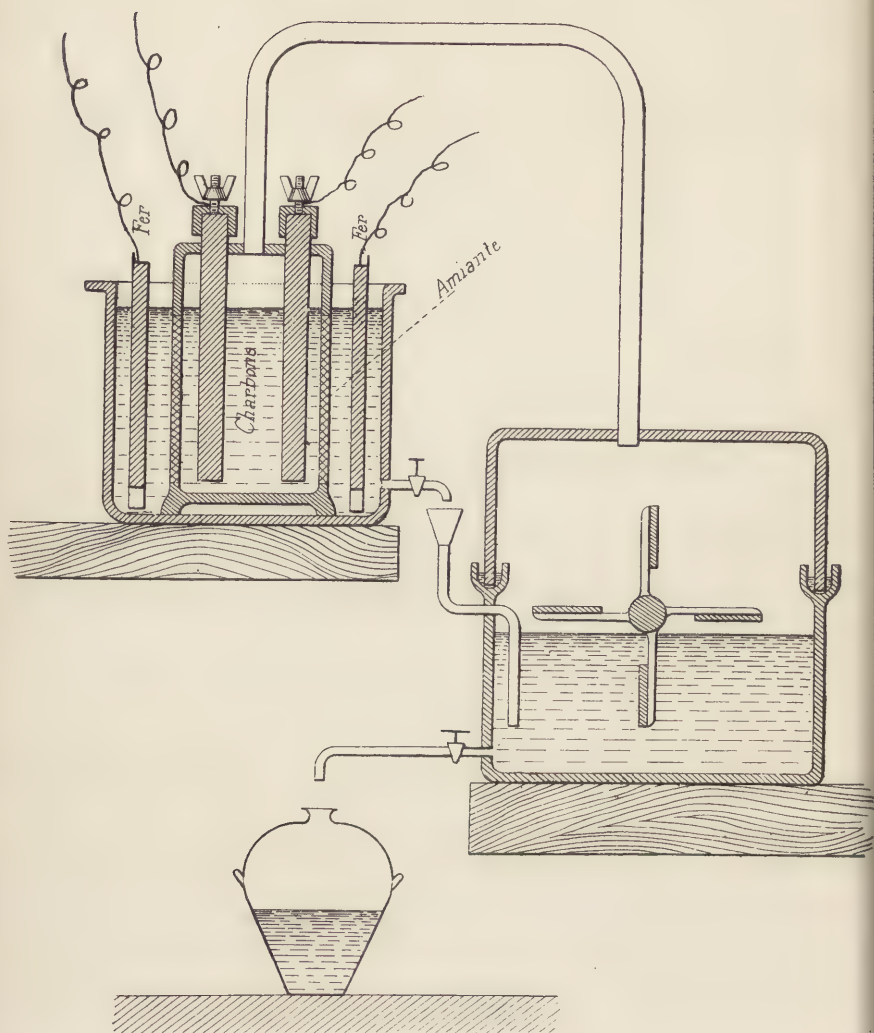


FIG. 20.—Leclanché's Electrolyser.

*Leclanché's Apparatus.*—In the two examples of apparatus which have been described the formation of hypochlorite of soda is effected in presence of electrodes ; it is not possible, therefore, to obtain great chlorometric strength. By Leclanché's apparatus the same chlorometric strength may be obtained as by chemical methods.

The construction of this apparatus is illustrated in Fig. 20. The chlorine and soda are prevented from combining in presence of the electrodes ; they are collected separately and conveyed into another apparatus called an absorber, where they combine to form hypochlorite of soda. The anodes are made of special carbon and the cathodes of iron. A porous asbestos partition separates the carbon electrodes from the iron electrodes. The carbon electrodes are placed inside a case closed on the top and the sides of which are constituted by the asbestos partition. This partition separates the chlorine from the soda.

The soda, when it is concentrated to the desired strength, is collected in a reservoir, from which it is led into the absorber.

The chlorine is disengaged along the length of the carbons, and fills the upper part of the case, from which it is led by earthenware pipes into the absorber previously charged with soda. A mixer fitted with arms puts the soda in motion so that it may absorb the chlorine.

A liquid may thus be obtained titrating 15, 20, 25, 30 and 35 chlorometric degrees, depending on the strength of the soda which is in the absorber.

The salt solution is concentrated to 22° to 24° Baumé. It contains about 250 *grammes* of salt per *litre*. The quantity of salt utilised varies between 50 and 95 per cent., but it is not advisable to endeavour to exceed this limit, as the electric yield is much diminished.

In each particular case a decision has to be come to as

to whether it is more advisable to economise salt or motive power, and consequently what is the most advantageous chlorometric strength to produce.

*Cost of Production.*—The cost depends on the plant already in existence in the works, and the extent of the new plant which it is desired to instal. The following example is given to show the economy of the process:—

Suppose a hydraulic force of 20-horse power is at disposal, 40 *litres* of hypochlorite of soda of 15 degrees chlorometric strength can be produced hourly with a dynamo of 100 volts, 100 ampères or 10,000 watts; there is every interest therefore to work twenty out of the twenty-four hours. There will thus be produced 800 *litres* of this liquid daily equal to 400 *kilogrammes* of hypochlorite of soda of 30° chlorometric strength, the price of which varies in different countries from 15 to 18 francs the 100 *kilogrammes*—say a quantity of hypochlorite which costs 60 to 72 francs on the market. The expense using Leclanché's apparatus would be:—

	Francs.
1. 800 <i>litres</i> of salt solution, 250 <i>grammes</i> per <i>litre</i> , the salt costing 5 francs the 100 <i>kilos.</i> , $800 \times 0.250 \text{ kilo.} \times 0.05 \text{ franc}$ - - - - -	10
2. Labour, attendance day and night - - - - -	8
3. Sundry expenses, lubrication, maintenance, wear and tear of carbons - - - - -	4
	<hr/> 22 <hr/>

This leaves 40 to 50 francs per day as profit and as a sinking fund to pay the cost of the plant.

Now an installation of this capacity costs:—

	Francs.
Cost of a dynamo - - - - -	2,500
Cost of erection, foundations, shafting, pulleys, belts - - -	2,500
Electrolyser and absorber - - - - -	10,000
Cost of erection, conducting cable, pump, reservoir, piping - -	3,000
	<hr/> 18,000 <hr/>



The plant pays for itself in a year and a half and afterwards an economy of 40 to 50 francs per day is effected.

When the motive power is produced by a steam engine it is necessary to add 1·2 *kilogramme* of coal per horse power per hour (a good Corliss engine hardly consumes 0·8 *kilogramme*), say an extra expense, reckoning coal at 20 francs the ton, of

$$20 \text{ hours} \times 20 \text{ H. P.} \times 1\cdot200 \text{ kilo.} \times 0\cdot02 \text{ fr.} = 9\cdot60 \text{ fr.}$$

With supplementary expenses the daily gain is reduced to 25 francs. In this latter case, if the bleacher does not take into account the advantages of greater security and the greater durability of the fabrics, there is no advantage in erecting a special engine for this purpose, but if the existing engine has 20 disposable horse power there will still be a profit of 7,500 francs annually after a two years' sinking fund.

If a hydraulic force of 40-horse power be at disposal, the economy realised will be much more considerable, because the working expenses remain practically the same and the cost of the first installation does not amount to much more.

The above examples of the production of electrolytic chlorides have been given by the author because he took part in the experiments the results of which are given above. But there are many other processes of producing decolourising chlorides by electrolysis. The above examples have been cited with the object of showing what may be expected from these processes and of enabling the reader to appreciate beforehand whether the particular circumstances under which he may be placed are such as to warrant him in hoping to be able to produce electrolytic chlorides advantageously.

#### LUNGE'S PROCESS FOR INCREASING THE INTENSITY OF THE BLEACHING POWER OF CHLORIDE OF LIME.

Professor Lunge uses an agent not formerly employed, *viz.*, a feeble acid such as formic acid or acetic acid. The price of the acetic acid is not an obstacle, because only small

quantities are required, and because this acid, being constantly regenerated, may be used for a long time. The acetic acid, in presence of chloride of lime, yields free hypochlorous acid and acetate of lime. During the process of bleaching the hydrochloric acid reacts on the acetate of lime, yielding chloride of calcium; the acetic acid is again liberated and the reaction is renewed a second time. The hydrochloric acid which is formed in the process of bleaching never remains in the free state, because it reacts on the acetate of lime, liberating acetic acid. This fact is of great importance, because hydrochloric acid reacts in an injurious manner on the fibre if it remain in contact with it for too long a time, whilst it is well known that acetic acid is quite harmless. As there is no formation of insoluble salts of lime, the souring operations which immediately succeed the chemick may be dispensed with; under these circumstances there is not only a decided economy, but, moreover, there is no danger of leaving a mineral acid on the fibre in consequence of imperfect washing and the damage to the fabrics attendant thereon, which is more especially to be feared in the case of thick fabrics.

Acetic acid may be used in different ways, either by adding it to the chemick, or by passing the fabrics through a weak sour after the ordinary chemick, or, moreover, by passing the fabrics through water slightly acidulated with acetic acid in which chloride of lime is introduced gradually.

It is asserted that if the process be well conducted there is every safety in the use of the chloride of lime, with the advantage that it is not necessary to dirty so much water. If any lye remain in the fabrics, or if the water be hard, or if the chemick contain caustic lime in excess, a larger quantity of acetic acid is required to neutralise the bases in the first place before liberating the hypochlorous acid. In this case it is economical to neutralise the free alkali or the lime by sulphuric or hydrochloric acid, and then to add the necessary quantity of acetic acid to produce the reaction.

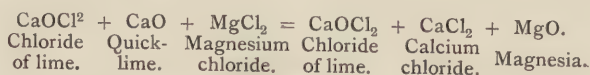
# TAILFER'S PROCESS FOR REMOVING THE EXCESS OF LIME OR SODA FROM DECOLOURISING CHLORIDES.

In order that the hypochlorites of lime and soda may be employed under the most favourable conditions for bleaching they should be neutral, that is to say, that the hypochlorite of lime should not contain an excess of lime, nor the hypochlorite of soda an excess of soda; because lime or soda in excess retards the bleaching power of the chlorides, and, what is more serious, lime acts injuriously on the textile fabrics. But, on the other hand, it is absolutely necessary that the chlorides of lime or soda contain an excess of lime or soda to enable them to be preserved, otherwise they would decompose very rapidly.

Generally, in order to remove the excess of lime or soda, resource is had to acids, sulphuric or hydrochloric, more rarely acetic. The two first, being very strong acids, violently attack the hypochlorites, and it is difficult in the actual practice of a bleach works to estimate the quantity of acid to use to remove the excess of base—lime or soda—alone, without attacking the hypochlorite. Now, if the hypochlorite be attacked there is a rapid disengagement of chlorine which attacks the textile fibres very energetically, and there is great reason to fear their being damaged. Acetic acid would be preferable, but its high price hinders its industrial use in connection with decolourising chlorides.

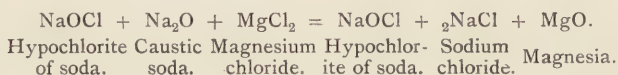
By the author's process the excess of lime or soda of the hypochlorites of lime or soda are removed, and that without decomposing the decolourising hypochlorite of lime, which is left in a neutral state.

In order to do this, chloride of magnesium is made to react on the hypochlorite of lime or soda. With chloride of lime the reaction is as follows:—



The magnesia, which is insoluble, is precipitated, the chloride of calcium remains in solution, and the hypochlorite properly so called is not attacked by the chloride of magnesia, even employed in excess.

If, instead of chloride of lime, chloride of soda (eau de Javelle, chlorozone, chlorogene, etc.) be acted on, the reaction is as follows :—



The chloride of sodium remains in solution, the magnesia is precipitated, and the hypochlorite of soda is left untouched.

The magnesium chloride may be used in the following manner :—

1. The chloride of lime is run off clear ; it generally indicates 7° to 10° Baumé, and it is strongly alkaline. To neutralise it magnesium chloride is added in sufficient quantity to transform the lime (CaO) in excess into chloride of calcium (CaCl<sub>2</sub>), which remains in solution. The magnesia is allowed to settle and the clear liquid drawn off.

2. When hypochlorite of soda is being treated the process is conducted in the same way, whatever may be the strength of the hypochlorite. The quantity of magnesium chloride to use is determined according to the excess of soda contained in the hypochlorite.

3. Instead of treating concentrated solutions of chloride of lime or hypochlorite of soda with magnesium chloride the operation may be performed on the chemicks, that is, on the concentrated solutions diluted with water, so as to bring them to the strength at which they are to be used for bleaching purposes. Magnesium chloride is added to destroy the excess of base, whether lime or soda, and the chemick is conducted in the usual way. No fear need be entertained in regard to the precipitate of magnesia ; it has no effect on the substances



to be bleached, and is removed by washing. It is easy to prove by a rapid experiment the advantages which may be gained by this process. With this end in view, two chemicks, for example, are made with hypochlorite of soda or eau de Javelle of the same strength. To the one a little chloride of magnesium is added to destroy the soda in excess, and the other chemick is left to do its work in the ordinary way. A swath of the same textile fabric is steeped in each chemick, and as the bleaching proceeds the following observations are made :—

1. That the fabric steeped in the chemick to which the chloride of magnesium was added bleaches more rapidly than the fabric plunged in the ordinary chemick.

2. That the fabric, even though left much longer in the ordinary chemick, does not become so white as that which was steeped in the chemick to which the chloride of magnesium was added.

3. That the strength of the fabric placed in the chemick to which the chloride of magnesium was added is not inferior to the strength of the textile chemicked in the ordinary way.

Magnesium chloride, used in conjunction with chloride of lime, increases the activity of the bleaching power, but, above all, it removes the excess of lime, changing it into calcium chloride, and it prevents the very injurious action of lime on textile fabrics, an action well known to all bleachers. This injurious action of lime is so much feared that many bleachers have given up the use of chloride of lime, substituting for it hypochlorite of soda, which is three times more costly, but does not contain lime. By the judicious employment of Tailfer's process, chloride of lime may be used with as much safety as hypochlorite of soda.

Bleachers who use hypochlorite of soda, eau de Javelle, or others, will find an appreciable advantage in the addition of chloride of magnesium to neutralise it by removing the excess



of soda which retards the bleaching power of the decolourising chloride. Very often the fabrics or yarns are not washed when they come out of the lye. The bleacher simply lets them drain and in this condition chemicks them. This is a saving of labour ; moreover, the goods to be bleached are still warm and in a spongy condition favourable to the penetration of the chemick ; but, on the other hand, the soda lye which they retain is opposed to the action of the chemick by diminishing its bleaching power. By taking care to previously add magnesium chloride to the chemick, the chloride of magnesia destroys the soda in excess ; the magnesia resulting from the reaction has no injurious effect on the fabrics and is removed by washing.

#### BLEACHING BY OZONE.

Attempts have been made for a long period to bleach textile fabrics by ozone, but till lately without obtaining results which enabled this process to be practically applied. For several years, Dr. Fröhlich, in conjunction with Messrs. Keperstein, bleachers of Greiffenberg, has made a special study of this particular question, and the results obtained by them have been such that they have been able to dispense with exposure on the grass, replacing the bleaching action of the green by that of ozone. Bleaching by ozone has been in daily use in the Greiffenberg bleach works for more than a year, and the daily production of linen yarn amounts to 500 *kilogrammes* of linen yarn daily.

Dr. Fröhlich first of all established by his own researches, as well as those of others, that bleaching by ozone alone did not yield good results, because the action of ozone acting by itself alone on linen for the purpose of bleaching is too great, and because the elasticity of the fibres suffers from it. By the ordinary processes linen is bleached by submitting it to the successive actions of soda lyes, chemicks, sours, and exposure on the green, these different operations being carried out and

repeated in convenient order. Instead of attempting to bleach by ozone alone, a mixed process has been tried in which the lye-boils, the chemicks and sours still figure ; but exposure on the green is replaced by treatment with ozone.

At the outset it was found in bleaching by ozone, just as in bleaching with chlorine, that the decolourising action is at its maximum at the beginning of the process, and if the operation be prolonged beyond measure the bleaching action is very weak, whilst, on the contrary, the injurious action of the chemicals increases rapidly. There is, therefore, great advantage in using these two agents during a very short time, and to proceed by a succession of feeble treatments. These two decolourising agents, chlorine and ozone, dovetail into each other in their functions in a really remarkable manner, the one preparing the fibre for the action of the other. Working in this way, favourable results were obtained first in the laboratory, then in a small ozone bleach works installed at Greiffenberg. The process has since been notably improved by moistening the hanks of yarn before treating with ozone with, for example, a weak solution of hydrochloric acid, spirits of turpentine and ammonia. The chemical reaction which takes place in consequence of the simultaneous action of one of these bodies with the ozone on linen fibres is not exactly known, as the study thereof is very difficult. It has been demonstrated simply that in consequence of the use of one of these substances the bleaching power was increased remarkably, without injuring the goods to be bleached. It is interesting to note that whilst the ozone penetrates into the oil of turpentine, dense white fumes are given off, the chemical action of which is not well known, but which possess a very great decolourising action.

Consequently, in the process described bleaching by ozone replaces bleaching by grass. Between the two there is still this difference. To the action of ozone must be added

that of the oxygenated compounds of nitrogen combined with ammonia and of peroxide of hydrogen, and the different compounds act in an extremely weak condition, whilst in bleaching by ozone the latter is employed alone, and in a much more concentrated condition.

In the Greiffenberg bleach works the process is used to bleach linen yarn in hanks, and the operation is conducted in the following manner :—

The hanks undergo the same operations, lye-boils, sours, chemicks, as in the old process, except that exposure on the grass is replaced by spreading in the ozone chamber. The hanks are moistened with one of the substances mentioned above and exposed in the ozone chamber, that is to say in a space enclosed in a suitable manner, where they remain exposed to the action of the ozone for six or seven hours. The hanks are then taken out of the chamber, they undergo another feeble process, and when they are dry they are three-quarters white. If a greater white still is required, this is done by a greater number of chemicks alternated with exposures in the ozone chamber. The yarn thus bleached presents as far as whiteness and elasticity is concerned all the qualities and appearances of yarn which has been bleached on the green. The cost is appreciably the same, but the great advantage of bleaching by ozone consists in dispensing with bleaching on the grass, by which the bleacher is enabled to accomplish all the operations inside the bleach works, and is able to work as well in winter as in summer. There is also a remarkable economy in time—about a third. The time which the bleaching process will last can also be foretold, so that deliveries may be made within a given time, which formerly was impossible.

At Greiffenberg in the ozone chamber the yarn is hung on poles in the same way as in ordinary drying machines.

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Ironrust and its Formation—Protection from Rusting by Paint—Grounding the Iron with Linseed Oil, etc.—Testing Paints—Use of Tar for Painting on Iron—Anti-corrosive Paints—Linseed Varnish—Chinese Wood Oil—Lead Pigments—Iron Pigments—Artificial Iron Oxides—Carbon—Preparation of Anti-corrosive Paints—Results of Examination of Several Anti-corrosive Paints—Paints for Ship's Bottoms—Anti-fouling Compositions—Various Anti-corrosive and Ship's Paints—Official Standard Specifications for Ironwork Paints—Index.

### Press Opinions.

"This is a very valuable book, translated from the German, discussing in detail anti-fouling and anti-corrosive paints."—*British Mercury*.

"Will be of great service to paint manufacturers, engineering contractors, ironfounders, shipbuilders and others."—*Engineer and Iron Trades Advertiser*.

"The book before us deals with the subject in a manner at once practical and scientific, and is well worthy of the attention of all builders, architects and engineers."—*The Builder*.

"The book is very readable and full of valuable information, and bearing in mind the importance of the subject treated, it is one which engineers will be well advised to procure at an early date."—*Railway Engineer*.

"The author goes fully into his subject, and the translator has been successful in reproducing in another language what he has to say. There are given in the text numerous illustrations of the rusting of iron, prepared in the course of a series of personal experiments on the formation of rust."—*Journal of Gas Lighting*.

"This work is a very elaborate and useful record of the various phenomena in connection with the corrosion of iron and its protection against corrosion. . . . The book is an exceedingly useful record of what has been done in connection with iron preservation, and will undoubtedly prove to be of much value to railway engineers, shipowners, etc."—*Fairplay*.

"This knowledge is conveyed with characteristic German thoroughness in this useful work of Herr Andés, which loses nothing of clearness in Mr. Salter's excellent translation. The causes of rust formation are examined, the proper methods of cleansing the ironwork detailed, and the constitution and application of suitable preventative coverings explained. . . . The book is a welcome contribution to technological literature, and will be found worthy of the careful study of all who are professionally engaged in the arrangement or superintendence of the class of work dealt with."—*Western Daily Mercury*.

"The author explains the nature of rust and its formation, and the text is illustrated from about fifty photographs. An immense amount of carefully arranged information follows as to the best methods of applying anti-corrosive substances and the various pigments most efficacious for use under all circumstances. The author has evidently thoroughly investigated and mastered the subject of iron corrosion, its cause and its prevention; and we regard his book as of the greatest importance to bridge-builders and makers and users of structural iron and steel. The book is illustrated throughout and is admirably indexed and arranged."—*Iron and Steel Trades Journal*.

"It is of the utmost importance to have reliable information on the various so-called infallible anti-corrosive paints which flood the market, and the large experience which evidently had been gained by the author in relation to the subject enables him to present in the work under notice an important contribution towards the solution of the problem involved, which is bound to prove extremely serviceable not only to paint manufacturers, but to engineers, contractors, ironfounders, shipbuilders and others. The subject is thoroughly dealt with in all its various

phases, and the vast fund of information afforded not only regarding rust formation and its prevention, but in reference to paints, varnishes, oils and pigments generally, should prove very valuable to the large class interested, while additional importance is given to the book by the numerous illustrations which were prepared by the author in the course of a series of personal experiments on the formation of rust."—*Builders' Reporter*.

"Herr Andés' book, written purely from a scientific standpoint, will be particularly useful to iron manufacturers, shipbuilders and shipowners. . . . The book is beautifully printed on good paper, and its appearance does credit to the publishers; the work of translation has been remarkably well done, the language bearing none of those irritating traces of Teutonism which disfigure so many English versions of German technical works."—*The Ironmonger*.

## SULPHATES OF ALUMINIUM AND IRON AND ALUM.

By LUCIEN GESCHWIND. Translated from the French. A Theoretical Study of Aluminium and Iron, their Manufacture, Industrial Applications, Analysis, Proportions and Methods of Analysis. About 400 pp. 195 Illustrations. *[In the Press.]*

## LUBRICATING OILS, FATS AND GREASES: Their

Origin, Preparation, Properties, Uses and Analyses. A Handbook for Oil Manufacturers, Refiners and Merchants, and the Oil and Fat Industry in General. By GEORGE H. HURST, F.C.S. Sixty-five Illustrations. 313 pp. 1896. Price 10s. 6d.; Abroad, 11s.; strictly net, post free.

### Contents.

Chapters I., **Introductory**. Oils and Fats, Fatty Oils and Fats, Hydrocarbon Oils, Uses of Oils.—II., **Hydrocarbon Oils**. Distillation, Simple Distillation, Destructive Distillation, Products of Distillation, Hydrocarbons, Paraffins, Olefins, Napthenes.—III., **Scotch Shale Oils**. Scotch Shales, Distillation of Scotch Oils, Shale Retorts, Products of Distilling Shales, Separating Products, Treating Crude Shale Oil, Refining Shale Oil, Shale Oil Stills, Shale Naphtha Burning Oils, Lubricating Oils, Wax.—IV., **Petroleum**. Occurrence, Geology, Origin, Composition, Extraction, Refining, Petroleum Stills, Petroleum Products, Cylinder Oils, Russian Petroleum, Deblooming Mineral Oils.—V., **Vegetable and Animal Oils**. Introduction, Chemical Composition of Oils and Fats, Fatty Acids, Glycerine, Extraction of Animal and Vegetable Fats and Oils, Animal Oils, Vegetable Oils, Rendering, Pressing, Refining, Bleaching, Tallow, Tallow Oil, Lard Oil, Neatsfoot Oil, Palm Oil, Palm Nut Oil, Coconut Oil, Castor Oil, Olive Oil, Rape and Colza Oils, Arachis Oil, Niger Seed Oil, Sperm Oils, Whale Oil, Seal Oil, Brown Oils, Lardine, Thickened Rape Oil.—VI., **Testing and Adulteration of Oils**. Specific Gravity, Alkali Tests, Sulphuric Acid Tests, Free Acids in Oils, Viscosity Tests, Flash and Fire Tests, Evaporation Tests, Iodine and Bromide Tests, Elaidin Test, Melting Point of Fat, Testing Machines.—VII., **Lubricating Greases**. Rosin Oil, Anthracene Oil, Making Greases, Testing and Analysis of Greases.—VIII., **Lubrication**. Friction and Lubrication, Lubricant, Lubrication of Ordinary Machinery, Spontaneous, Combustion of Oils, Stainless Oils, Lubrication of Engine Cylinders, Cylinder Oils.—**Appendices**. A. Table of Baume's Hydrometer—B. Table of Thermometric Degrees—C. Table of Specific Gravities of Oils—**Index**.

### Press Opinions.

"The book is well printed, and is a credit alike to author, printer and publisher."—*Textile Mercury*.

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"Mr. Hurst has in this work supplied a practical treatise which should prove of especial value to oil dealers, and also, though in a less degree, to oil users."—*Textile Manufacturer*.

"This is a clear and concise treatment of the method of manufacturing and refining lubricating oils. . . . The book is one which is well worthy the attention of readers who are users of oil."—*Textile Recorder*.



"We have no hesitation in saying that in our opinion this book ought to be very useful to all those who are interested in oils, whether as manufacturers or users of lubricants, or to those chemists or engineers whose duty it may be to report upon the suitability of the same for any particular class of work."—*Engineer*.

"The author is widely known and highly respected as an authority on the chemistry of oils and the technics of lubrication, and it is safe to say that no work of similar interest or equal value to the general oil-selling and consuming public has heretofore appeared in the English language."—*Drugs, Oils and Paints*, U.S.A.

"This valuable and useful work, which is both scientific and practical, has been written with a view of supplying those who deal in and use oils, etc., for the purpose of lubrication with some information respecting the special properties of the various products which cause these various oils to be of value as lubricants."—*Industries and Iron*.

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**THE MANUFACTURE OF VARNISHES, OIL REFINING AND BOILING, AND KINDRED INDUSTRIES.** Describing the Manufacture of Spirit Varnishes and Oil Varnishes; Raw Materials: Resins, Solvents and Colouring Principles; Drying Oils: their Properties, Applications and Preparation by both Hot and Cold Processes; Manufacture, Employment and Testing of Different Varnishes. Translated from the French of ACH. LIVACHE, Ingénieur Civil des Mines. Greatly Extended and Adapted to English Practice, with numerous Original Recipes. By JOHN GEDDES MCINTOSH, Lecturer on Oils, Colours and Varnishes, Regent Street Polytechnic. Twenty-seven Illustrations. 400 pp. 1899. Price 12s. 6d.; Abroad, 13s.; strictly net, post free.

### Contents.

I. Resins: Gum Resins, Oleo Resins and Balsams, Commercial Varieties, Source, Collection, Characteristics, Chemical Properties, Physical Properties, Hardness, Adulterations, Appropriate Solvents, Special Treatment, Special Use.—II. Solvents: Natural, Artificial, Manufacture, Storage, Special Use.—III. Colouring: Principles, (1) Vegetable, (2) Coal Tar, (3) Coloured Resinates, (4) Coloured Oleates and Linoleates.—Gum Running: Furnaces, Bridges, Flues, Chimney Shafts, Melting Pots, Condensers, Boiling or Mixing Pans, Copper Vessels, Iron Vessels (Cast), Iron Vessels (Wrought), Iron Vessels (Silvered), Iron Vessels (Enamelled), Steam Superheated Plant, Hot-air Plant.—Spirit Varnish Manufacture: Cold Solution Plant, Mechanical Agitators, Hot Solution Plant, Jacketted Pans, Mechanical Agitators, Clarification and Filtration, Bleaching Plant, Storage Plant.—Manufacture, Characteristics and Uses of the Spirit Varnishes yielded by: Amber, Copal, Dammar, Shellac, Mastic, Sandarac, Rosin, Asphalt, India Rubber, Gutta Percha, Collodion, Celluloid, Resinates, Oleates.—Manufacture of Varnish Stains.—Manufacture of Lacquers.—Manufacture of Spirit Enamels.—Analysis of Spirit Varnishes.—Physical and Chemical Constants of Resins.—Table of Solubility of Resins in different Menstrua.—Systematic qualitative Analysis of Resins, Hirschop's tables.—Drying Oils: Oil Crushing Plant, Oil Extraction Plant, Individual Oils, Special Treatment of Linseed Oil, Poppyseed Oil, Walnut Oil, Hempseed Oil, Llamantia Oil, Japanese Wood Oil, Gurjun Balsam, Climatic Influence on Seed and Oil.—Oil Refining: Processes, Thenard's, Liebig's, Filtration, Storage, Old Tanked Oil.—Oil Boiling: Fire Boiling Plant, Steam Boiling Plant, Hot-Air Plant, Air Pumps, Mechanical Agitators, Vincent's Process, Hadfield's Patent, Storer's Patent, Walton's Processes, Continental Processes, Pale Boiled Oil, Double Boiled Oil, Hartley and Blenkinsop's Process.—Driers: Manufacture, Special Individual Use of (1) Litharge, (2) Sugar of Lead, (3) Red Lead, (4) Lead Borate, (5) Lead Linoleate, (6) Lead Resinate, (7) Black Oxide of Manganese, (8) Manganese Acetate, (9) Manganese Borate, (10) Manganese Resinate, (11) Manganese Linoleate, Mixed Resinates and Linoleates, Manganese and Lead, Zinc Sulphate, Terebine, Liquid Driers.—Solidified Boiled Oil.—Manufacture of Linoleum.—Manufacture of India Rubber Substitutes.—Printing Ink Manufacture.—Lithographic Ink Manufacture.—Manufacture of Oil Varnishes.—Running

and Special Treatment of Amber, Copal, Kauri, Manilla.—Addition of Oil to Resin.—Addition of Resin to Oil.—Mixed Processes.—Solution in Cold of previously Fused Resin.—Dissolving Resins in Oil, etc., under pressure.—Filtration.—Clarification.—Storage.—Ageing.—Coach-makers' Varnishes and Japans.—Oak Varnishes.—Japanners' Stoving Varnishes.—Japanners' Gold Size.—Brunswick Black.—Various Oil Varnishes.—Oil-Varnish Stains.—Varnishes for "Enamels".—India Rubber Varnishes.—Varnishes Analysis: Processes, Matching.—Faults in Varnishes: Cause, Prevention.—Experiments and Exercises.

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"23rd May, 1899."

**THE MANUFACTURE OF LAKE PIGMENTS FROM ARTIFICIAL COLOURS.** By FRANCIS H. JENNISON, F.I.C., F.C.S. Fifteen Plates. 135 pp. 1900. Price 7s. 6d.; Abroad, 8s.; strictly net, post free.

### Contents.

Chapters I., Introduction.—II., The Groups of the Artificial Colouring Matters.—III., The Nature and Manipulation of Artificial Colours.—IV., Lake-forming Bodies for Acid Colours.—V., Lake-forming Bodies' Basic Colours.—VI., Lake Bases.—VII., The Principles of Lake Formation.—VIII., Red Lakes.—IX., Orange, Yellow, Green, Blue, Violet and Black Lakes.—X., The Production of Insoluble Azo Colours in the Form of Pigments.—XI., The General Properties of Lakes Produced from Artificial Colours.—XII., Washing, Filtering and Finishing.—XIII., Matching and Testing Lake Pigments.—Index.

**THE TESTING AND VALUATION OF RAW MATERIALS USED IN PAINT AND COLOUR MANUFACTURE.** By M. W. JONES, F.C.S. A Book for the Laboratories of Colour Works. 88 pp. 1900. Price 5s.; Abroad, 5s. 6d.; strictly net, post free.

### Contents.

Aluminium Compounds. China Clay. Iron Compounds. Potassium Compounds. Sodium Compounds. Ammonium Hydrate. Acids. Chromium Compounds. Tin Compounds. Copper Compounds. Lead Compounds. Zinc Compounds. Manganese Compounds. Arsenic Compounds. Antimony Compounds. Calcium Compounds. Barium Compounds. Cadmium Compounds. Mercury Compounds. Ultramarine. Cobalt and Carbon Compounds. Oils Index.



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"Though this excellent little work can appeal only to a limited class, the chemists in colour works, yet it will appeal to them very strongly indeed, for it will put them on the track of short, rapid, and yet approximately, accurate methods of testing the comparative value of competing samples of raw material used in paint and colour manufacture."—*North British Daily Mail*.

"This little text-book is intended to supplement the larger and more comprehensive works on the subject, and it embodies the result of Mr. Jones' experiments and experiences, extending over a long period. It gives, under separate headings, the principal ingredients and impurities found in the raw materials, and is a handy work of reference for ascertaining what is valuable or detrimental in the sample under examination."—*Blackburn Times*.

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**THE CHEMISTRY OF ESSENTIAL OILS AND ARTIFICIAL PERFUMES.** By ERNEST J. PARRY, B.Sc. (Lond.), F.I.C., F.C.S. Illustrated with Twenty Engravings. 400 pp. 1899. Price 12s. 6d.; Abroad, 14s.; strictly net, post free.

### Contents.

Chapters I., The General Properties of Essential Oils.—II., Compounds occurring in Essential Oils.—III., The Preparation of Essential Oils.—IV., The Analysis of Essential Oils.—V., Systematic Study of the Essential Oils.—VI., Terpeneless Oils.—VII., The Chemistry of Artificial Perfumes.—Appendix: Table of Constants.

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"There can be no doubt that the publication will take a high place in the list of scientific text-books."—*London Argus*.

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"At various times monographs have been printed by individual workers, but it may safely be said that Mr. Parry is the first in these latter days to deal with the subject in an adequate manner. His book is well conceived and well written. . . . He is known to have sound practical experience in analytical methods, and he has apparently taken pains to make himself *au fait* with the commercial aspects of the subject."—*Chemist and Druggist*.

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**DRYING OILS, BOILED OIL AND SOLID AND LIQUID DRIERS.** By L. E. ANDÉS. Forty-two Illustrations. A Practical Work for Manufacturers of Oils, Varnishes, Printing Inks, Oilcloth and Linoleum, Oilcakes, Paints, etc. Expressly Written for this Series of Special Technical Books, and the Publishers hold the Copyright for English and Foreign Editions. [In the Press]

## Contents.

Chapters I., General Chemical and Physical Properties of the Drying Oils: Cause of the Drying Property; Absorption of Oxygen; Behaviour towards Metallic Oxides, etc.—II., The Properties of and Methods for obtaining the Drying Oils.—III., Production of the Drying Oils by Expression and Extraction; Refining and Bleaching; Oil Cakes and Meal; The Refining and Bleaching of the Drying Oils; The Bleaching of Linseed Oil.—IV., The Manufacture of Boiled Oil; The Preparation of Drying Oils for Use in the Grinding of Paints and Artists' Colours and in the Manufacture of Varnishes by Heating over a Fire or by Steam, by the Cold Process, by the Action of Air, and by Means of the Electric Current; The Driers used in Boiling Linseed Oil; The Manufacture of Boiled Oil and the Apparatus therefor; Livache's Process for Preparing a Good Drying Oil and its Practical Application.—V., The Preparation of Varnishes for Letterpress, Lithographic and Copperplate Printing, for Oilcloth and Waterproof Fabrics; The Manufacture of Thickened Linseed Oil, Burnt Oil, Stand Oil by Fire Heat, Superheated Steam, and by a Current of Air.—VI., Behaviour of the Drying Oils and Boiled Oils towards Atmospheric Influences, Water, Acids and Alkalies.—VII., Boiled Oil Substitutes.—VIII., The Manufacture of Solid and Liquid Driers from Linseed Oil and Rosin; Linolic Acid Compounds of the Driers.—IX., The Adulteration and Examination of the Drying Oils and Boiled Oil.

**GLUE AND GLUE TESTING.** By SAMUEL RIDEAL, D.Sc.  
 Lond., F.I.C. Fourteen Engravings. 144 pp. 1900. Price 10s. 6d.;  
 Abroad, 11s.; strictly net, post free.

## Contents.

Chapters I., **Constitution and Properties:** Definitions and Sources, Gelatine, Chondrin and Allied Bodies, Physical and Chemical Properties, Classification, Grades and Commercial Varieties.—II., **Raw Materials and Manufacture:** Glue Stock, Lining, Extraction, Washing and Clarifying, Filter Presses, Water Supply, Use of Alkalies, Action of Bacteria and of Antiseptics, Various Processes, Cleansing, Forming, Drying, Crushing, etc., Secondary Products.—III., **Uses of Glue:** Selection and Preparation for Use, Carpentry, Veneering, Paper-Making, Bookbinding, Printing Rollers, Hectographs, Match Manufacture, Sandpaper, etc., Substitutes for other Materials, Artificial Leather and Caoutchouc.—IV., **Gelatine:** General Characters, Liquid Gelatine, Photographic Uses, Size, Tanno-, Chrome and Formo-Gelatine, Artificial Silk, Cements, Pneumatic Tyres, Culinary, Meat Extracts, Isinglass, Medicinal and other Uses, Bacteriology.—V., **Glue Testing:** Review of Processes, Chemical Examination, Adulteration, Physical Tests, Valuation of Raw Materials.—VI., **Commercial Aspects.**

## Press Opinions.

"This work is of the highest technical character, and gives not only a full and practical account of the raw materials and manufacture of glues, gelatines and similar substances, but gives many hints and information on the use of such substances in veneering, carpentry and many other purposes. Many tests are given for glue in different stages of the progress of its manufacture, and the commercial value of a commodity so much in general use is exemplified by statistics and figures. It is certainly a valuable treatise upon an article for which very little literature in any form has previously been obtainable."—*Carpenter and Builder*.

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**PURE AIR, OZONE AND WATER.** A Practical Treatise of their Utilisation and Value in Oil, Grease, Soap, Paint, Glue and other Industries. By W. B. COWELL. Twelve Illustrations. 1900. Price 5s.; Abroad, 5s. 6d.; strictly net, post free.

#### Contents.

Chapters I., Atmospheric Air; Lifting of Liquids; Suction Process; Preparing Blown Oils; Preparing Siccative Drying Oils.—II., Compressed Air; Whitewash.—III., Liquid Air; Retrocession.—IV., Purification of Water; Water Hardness.—V., Fleshings and Bones.—VI., Ozonised Air in the Bleaching and Deodorising of Fats, Glues, etc.; Bleaching Textile Fibres.—Appendix: Air and Gases; Pressure of Air at Various Temperatures; Fuel; Table of Combustibles; Saving of Fuel by Heating Feed Water; Table of Solubilities of Scale Making Minerals; British Thermal Units Tables; Volume of the Flow of Steam into the Atmosphere; Temperature of Steam.—Index.

#### Press Opinions.

"This is a valuable work in little space. . . . In arrangement it is a commendable work, and its value is increased by the index which brings the little volume to a close."—*Newcastle Daily Journal*.

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**THE MANUFACTURE OF MINERAL AND LAKE PIGMENTS.** Containing Directions for the Manufacture of all Artificial, Artists and Painters' Colours, Enamel, Soot and Metallic Pigments. A Text-book for Manufacturers, Merchants, Artists and Painters. By DR. JOSEF BERSCH. Translated from the Second Revised Edition by ARTHUR C. WRIGHT, M.A. (Oxon.), B.Sc. (Lond.), formerly Assistant Lecturer and Demonstrator in Chemistry at the Yorkshire College, Leeds. Forty-three Illustrations. Price 12s. 6d.; Abroad, 13s.; strictly net, post free. *[In the Press.]*

**THE RISKS AND DANGERS OF VARIOUS OCCUPATIONS AND THEIR PREVENTION.** By LEONARD A. PARRY, M.D., B.S. (Lond.). 1900. Price 7s. 6d.; Abroad, 8s.; strictly net, post free.

#### Contents.

Chapters I., Occupations which are Accompanied by the Generation and Scattering of Abnormal Quantities of Dust.—II., Trades in which there is Danger of Metallic Poisoning.—III., Certain Chemical Trades.—IV., Some Miscellaneous Occupations.—V., Trades in which Various Poisonous Vapours are Inhaled.—VI., General Hygienic Considerations.—Index.

☞ This book contains valuable information for the following trades—Aerated Water Manufacture, Alkali Manufacture, Aniline Manufacture, Barometer Making, Brass Founders, Bromine Manufacture, Bronze Moulders, Brush Making, Builders, Cabinet Makers, Calico Printing, Chloride of Lime Manufacture, Coal Miners, Cocoa-nut Fibre Making, Colour Grinders, Copper Miners, Cotton Goods Manufacture, Cotton Yarn Dyeing, Cutlery Trades, Dry Cleaning, Electricity Generating, Electroplaters, Explosives Manufacture, File Making, Flint Milling, Floor Cloth Makers, Furriers, Fustian Clothing Making, Galvanised Iron Manufacture, Gassing Process, Gilders, Glass Making, Glass Paper Making, Glass Polishing and Cutting,



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### Press Opinions.

"The language used is quite simple, and can be understood by any intelligent person engaged in the trades dealt with."—*The Clarion*.

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### Contents.

I., Behaviour of the Paper Fibres during the Process of Dyeing, Theory of the Mordant—Cotton; Flax and Hemp; Esparto; Jute; Straw Cellulose; Chemical and Mechanical Wood Pulp; Mixed Fibres; Theory of Dyeing.—II., Colour Fixing Mediums (Mordants)—Alum; Aluminium Sulphate; Aluminium Acetate; Tin Crystals (Stannous Chloride); Cupperas (Ferrous Sulphate); Nitrate of Iron (Ferric Sulphate); Pyrolignite of Iron (Acetate of Iron); Action of Tannic Acid; Importance of Materials containing Tannin; Treatment with Tannic Acid of Paper Pulp intended for dyeing; Blue Stone (Copper Sulphate); Potassium Bichromate; Sodium Bichromate; Chalk (Calcium Carbonate); Soda Crystals (Sodium Carbonate); Antimony Potassium Tartrate (Tartar Emetic).—III., Influence of the Quality of the Water Used.—IV., Inorganic Colours.—1. Artificial Mineral Colours: Iron Buff; Manganese Bronze; Chrome Yellow (Chromate of Lead); Chrome Orange (Basic Chromate of Lead); Red Lead; Chrome Green; Blue with Yellow Prussiate; Prussian Blue; Method for Producing Prussian Blue free from Acid; Ultramarine.—2. Natural Mineral Colours (Earth



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## Enamelling on Metal.

### ENAMELS AND ENAMELLING. An Introduction to the

Preparation and Application of all Kinds of Enamels for Technical and Artistic Purposes. For Enamel Makers, Workers in Gold and Silver, and Manufacturers of Objects of Art. By PAUL RANDAU. Translated from the German. With Sixteen Illustrations. 180 pp. 1900. Price 10s. 6d.; Abroad, 11s.; strictly net, post free.

#### Contents.

I., Introduction.—II., Composition and Properties of Glass.—III., Raw Materials for the Manufacture of Enamels.—IV., Substances Added to Produce Opacity.—V., Fluxes.—VI., Pigments.—VII., Decolorising Agents.—VIII., Testing the Raw Materials with the Blow-pipe Flame.—IX., Subsidiary Materials.—X., Preparing the Materials for Enamel Making.—XI., Mixing the Materials.—XII., The Preparation of Technical Enamels, The Enamel Mass.—XIII., Appliances for Smelting the Enamel Mass.—XIV., Smelting the Charge.—XV., Composition of Enamel Masses.—XVI., Composition of Masses for Ground Enamels.—XVII., Composition of Cover Enamels.—XVIII., Preparing the Articles for Enamelling.—XIX., Applying the Enamel.—XX., Firing the Ground Enamel.—XXI., Applying and Firing the Cover Enamel or Glaze.—XXII., Repairing Defects in Enamelled Ware.—XXIII., Enamelling Articles of Sheet Metal.—XXIV., Decorating Enamelled Ware.—XXV., Specialities in Enamelling.—XXVI., Dial-plate Enamelling.—XXVII., Enamels for Artistic Purposes, Recipes for Enamels of Various Colours.—Index.

### Press Opinions.

"Mr. Hermann, by a careful division of his subject, avoids much repetition, yet makes sufficiently clear what is necessary to be known in each art. He gives very many formulæ; and his hints on the various applications of metals and metallic lustres to glass and porcelains will be found of much interest to the amateur."—*Art Amateur*, New York.

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"The compiler displays that painstaking research characteristic of his nation, and goes at length into the question of the chemical constitution of the pigments and fluxes to be used in glass-painting, proceeding afterwards to a description of the methods of producing coloured glass of all tints and shades. . . . Very careful instructions are given for the chemical and mechanical preparation of the colours used in glass-staining and porcelain-painting; indeed, to the china painter such a book as this should be of permanent value, as the author claims to have tested and verified every recipe he includes, and the volume also comprises a section devoted to enamels both opaque and translucent, and another treating of the firing of porcelain, and the accidents that occasionally supervene in the furnace."—*Daily Chronicle*.

"In Dr. Hermann's hand-book—if such a term is fitting for so erudite and masterly a treatise—the student is first delighted by an interesting historical introduction, after which an exhaustive description follows of the metallic oxides and salts, the earths and earthy bodies and the free metals used in the composition of the pigments. All who take an interest in the colouring properties of matter will not fail to be instructed in this section of the work. . . . Exhaustive recipes are given in separate chapters for the composition of the colours and fluxes for every shade and tint in the painting of glass, porcelain, enamel, faience, and stone-ware, for the preparation of coloured pastes, for the application of metallic ornamentation, for the colouring of the foundation in the 'frit' or 'charge' stage, and for the encaustic operations in the kiln. . . . In every district of England where art porcelain and glass is manufactured, this treatise should be widely circulated, and its contents made familiar to all engaged, in whatever capacity, in the trade."—*Leeds Mercury*.

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## THE HISTORY OF THE STAFFORDSHIRE POTTERIES; AND THE RISE AND PROGRESS OF THE MANUFACTURE OF POTTERY AND PORCELAIN.

With References to Genuine Specimens, and Notices of Eminent Potters. By SIMEON SHAW. (Originally Published in 1829.) 265 pp. 1900. Price 7s. 6d.; Abroad, 8s.; strictly net, post free.

### Contents.

**Introductory Chapter** showing the position of the Pottery Trade at the present time (1899).—**Chapters I., Preliminary Remarks.**—II., **The Potteries**, comprising Tunstall, Brownhills, Greenfield and New Field, Golden Hill, Latebrook, Green Lane, Burslem, Longport and Dale Hall, Hot Lane and Cobridge, Hanley and Shelton, Etruria, Stoke, Penkhull, Fenton, Lane Delph, Foley, Lane End.—III., **On the Origin of the Art**, and its Practice among the early Nations.—IV., **Manufacture of Pottery**, prior to 1700.—V., **The Introduction of Red Porcelain** by Messrs. Elers, of Bradwell, 1690.—VI., **Progress of the Manufacture** from 1700 to Mr. Wedgwood's commencement in 1760.—VII., **Introduction of Fluid Glaze**.—Extension of the Manufacture of Cream Colour.—Mr. Wedgwood's Queen's Ware.—Jasper, and Appointment of Potter to Her Majesty.—Black Printing.—VIII., **Introduction of Porcelain**. Mr. W. Littler's Porcelain.—Mr. Cookworthy's Discovery of Kaolin and Petuntse, and Patent.—Sold to Mr. Champion—resold to the New Hall Com.—Extension of Term.—IX., **Blue Printed Pottery**. Mr. Turner, Mr. Spode (1), Mr. Baddeley, Mr. Spode (2), Messrs. Turner, Mr. Wood, Mr. Wilson, Mr. Minton.—Great Change in Patterns of Blue Printed.—X., **Introduction of Lustre Pottery**. Improvements in Pottery and Porcelain subsequent to 1800.

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### A Reissue of

**THE CHEMISTRY OF THE SEVERAL NATURAL AND ARTIFICIAL HETEROGENEOUS COMPOUNDS USED IN MANUFACTURING PORCELAIN, GLASS AND POTTERY.** By SIMEON SHAW.  
(Originally published in 1837.) 750 pp. 1900. Price 14s.; Abroad, 14s. 6d.; strictly net, post free.

### Contents.

**PART I., ANALYSIS AND MATERIALS.**—Chapters I., **Introduction**: Laboratory and Apparatus; **Elements**: Combinative Potencies, Manipulative Processes for Analysis and Reagents, Pulverisation, Blow-pipe Analysis, Humid Analysis, Preparatory Manipulations, General Analytic Processes, Compounds Soluble in Water, Compounds Soluble only in Acids, Compounds (Mixed) Soluble in Water, Compounds (Mixed) Soluble in Acids, Compounds (Mixed) Insoluble, Particular Analytic Processes.—II., **Temperature**: Coal, Steam Heat for Printers' Stoves.—III., **Acids and Alkalies**: Boracic Acid, Muriatic Acid, Nitric Acid, Sulphuric Acid, Potash, Soda, Lithia, Calculation of Chemical Separations.—IV., **The Earths**: Alumina, Clays, Silica, Flint, Lime, Plaster of Paris, Magnesia, Barytes, Felspar, Grauen (or China Stone), China Clay, Chert.—V., **Metals**: Reciprocal Combinative Potencies of the Metals, Antimony, Arsenic, Chromium, Green Oxide, Cobalt, Chromic Acid, Humid Separation of Nickel from Cobalt, Arsenite of Cobalt, Copper, Gold, Iron, Lead, Manganese, Platinum, Silver, Tin, Zinc.

**PART II., SYNTHESIS AND COMPOUNDS.**—Chapters I., Sketch of the Origin and Progress of the Art.—II., **Science of Mixing**: Scientific Principles of the Manufacture, Combinative Potencies of the Earths.—III., **Bodies**: Porcelain—Hard, Porcelain—Fritted Bodies, Porcelain—Raw Bodies, Porcelain—Soft, Fritted Bodies, Raw Bodies, Stone Bodies, Ironstone, Dry Bodies, Chemical Utensils, Fritted Jasper, Fritted Pearl, Fritted Drab, Raw Chemical Utensils, Raw Stone, Raw Jasper, Raw Pearl, Raw Mortar, Raw Drab, Raw Brown, Raw Fawn, Raw Cane, Raw Red Porous, Raw Egyptian, Earthenware, Queen's Ware, Cream Colour, Blue and Fancy Printed, Dipped and Mocha, Chalky, Rings, Stilts, etc.—IV., **Glasses**: Porcelain—Hard Fritted, Porcelain—Soft Fritted, Porcelain—Soft Raw, Cream Colour Porcelain, Blue Printed Porcelain, Fritted Glazes, Analysis of Fritt, Analysis of Glaze, Coloured Glazes, Dips, Smears and Washes: **Glasses**: Flint Glass, Coloured Glasses, Artificial Garnet, Artificial Emerald, Artificial Amethyst, Artificial Sapphire, Artificial Opal, Plate Glass, Crown Glass, Broad Glass, Bottle Glass, Phosphoric Glass, British Steel Glass, Glass-Staining and Painting, Engraving on Glass, Dr. Faraday's Experiments.—V., **Colours**: Colour Making, Fluxes or Solvents, Components of the Colours: **Reds, etc., from Gold**, Carmine or Rose Colour, Purple, Reds, etc., from Iron, Blues, Yellows, Greens, Blacks, White, Silver for Burnishing, Gold for Burnishing, Printer's Oil, Lustres.

**PART III., TABLES OF THE CHARACTERISTICS OF CHEMICAL SUBSTANCES.**—Preliminary Remarks, Oxygen (Tables), Sulphur and its Compounds, Nitrogen ditto, Chlorine ditto, Bromine ditto, Iodine ditto, Fluorine ditto, Phosphorous ditto, Boron ditto, Carbon ditto, Hydrogen ditto, Observations, Ammonium and its Compounds (Tables), Thorium ditto, Zirconium ditto, Aluminium ditto, Yttrium ditto, Glucinum ditto, Magnesium ditto, Calcium ditto, Strontium ditto, Barium ditto, Lithium ditto, Sodium and its Compounds,



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## THE ART OF ENAMELLING ON METAL. By W.

NORMAN BROWN. Twenty-eight Illustrations. 60 pp. 1900. Price 2s. 6d.; strictly net, post free.

### Contents.

Chapters I., History—Cloisonné—Champs Levé—Translucent Enamel—Surface Painted Enamels.—II., Cloisonné—Champs Levés—Translucent—Painted.—III., Painted Enamel—Apparatus—Furnaces and Muffles for Firing.—IV., The Copper Base or Plate—Planishing—Cloisons—Champ Levé Plates.—V., Enamels—Trituration—Washing—Coating a Plate with Enamel—Firing Ordinary Plaques for Painting—Designing—Squaring off.—VI., Designs for Cloisonné—Designs for Painted Enamels—Technical Processes—Brushes, etc.—Colours—Grisaille—Full-coloured Designs.

### Press Opinion.

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## Books on Textile and Dyeing Subjects.

**THE TECHNICAL TESTING OF YARNS AND TEXTILE FABRICS.** With Reference to Official Specifications. Translated from the German of Dr. J. HERZFELD. Sixty-nine Illustrations. 200 pp. 1898. Price 10s. 6d.; Abroad, 11s.; strictly net, post free.

### Contents.

Yarn Testing. III., Determining the Yarn Number.—IV., Testing the Length of Yarns.—V., Examination of the External Appearance of Yarn.—VI., Determining the Twist of Yarn and Twist.—VII., Determination of Tensile Strength and Elasticity.—VIII., Estimating the Percentage of Fat in Yarn.—IX., Determination of Moisture (Conditioning).—Appendix.

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## DECORATIVE AND FANCY TEXTILE FABRICS.

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### Contents.

Chapters I., A Few Hints on Designing Ornamental Textile Fabrics.—II., A Few Hints on Designing Ornamental Textile Fabrics (continued).—III., A Few Hints on Designing Ornamental Textile Fabrics (continued).—IV., A Few Hints on Designing Ornamental Textile Fabrics (continued).—V., Hints for Ruled-paper Draughtsmen.—VI., The Jacquard Machine.—VII., Brussels and Wilton Carpets.—VIII., Tapestry Carpets.—IX., Ingrain Carpets.—X., Axminster Carpets.—XI., Damask and Tapestry Fabrics.—XII., Scarf Silks and Ribbons.—XIII., Silk Handkerchiefs.—XIV., Dress Fabrics.—XV., Mantle Cloths.—XVI., Figured Plush.—XVII., Bed Quilts.—XVIII., Calico Printing.



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### Contents.

I., **Power-Loom Weaving in General.** Various Systems of Looms.—II., **Mounting and Starting the Power-Loom.** English Looms.—Tappet or Treadle Looms.—Dobbies.—III., **General Remarks on the Numbering, Reeling and Packing of Yarn.**—**Appendix.**—**Useful Hints.** Calculating Warps.—Weft Calculations.—Calculations of Cost Price in Hanks.

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"The book under notice is intended as an instructor to those engaged in power-loom weaving, and, judging by its compilation, the author is a thorough master of the craft. It is not overloaded with details, and he manages to compress in a book of some 150 pages all that one can possibly wish to know about the different parts of the machinery, whether of English or foreign make, and for whatever kind of cloth required. A comprehensive summary is also included of the various yarns and methods of numbering them, as well as a few useful hints and a number of coloured diagrams for mandarin weavings. The book is printed in bold, legible type, on good paper, has a copious index, and is well and strongly bound."—*Ashton-under-Lyne Herald*.

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**COLOUR: A HANDBOOK OF THE THEORY OF COLOUR.** By GEORGE H. HUSRT, F.C.S. With Ten Coloured Plates and Seventy-two Illustrations. 160 pp. 1900. Price 7s. 6d.; Abroad, 8s.; strictly net, post free.

### Contents.

Chapters I., **Colour and Its Production.** Light, Colour, Dispersion of White Light Methods of Producing the Spectrum, Glass Prism and Diffraction Grating Spectroscopes, The Spectrum, Wave Motion of Light, Recomposition of White Light, Hue, Luminosity, Purity of Colours, The Polariscopes, Phosphorescence, Fluorescence, Interference.—II., **Cause of Colour in Coloured Bodies.** Transmitted Colours, Absorption Spectra of Colouring Matters.—III., **Colour Phenomena and Theories.** Mixing Colours, White Light from Coloured Lights, Effect of Coloured Light on Colours, Complementary Colours, Young-Helmholtz Theory, Brewster Theory, Supplementary Colours, Maxwell's Theory, Colour Photography.—IV., **The Physiology of Light.** Structure of the Eye, Persistence of Vision, Subjective Colour Phenomena, Colour Blindness.—V., **Contrast.** Contrast, Simultaneous Contrast, Successive Contrast, Contrast of Tone, Contrast of Colours, Modification of Colours by Contrast, Colour Contrast in Decorative Design.—VI., **Colour in Decoration and Design.** Colour Harmonies, Colour Equivalents, Illumination and Colour, Colour and Textile Fabrics, Surface Structure and Colour.—VII., **Measurement of Colour.** Colour Patch Method, The Tintometer, Chromometer.

### Press Opinions.

"This useful little book possesses considerable merit, and will be of great utility to those for whom it is primarily intended."—*Birmingham Post*.

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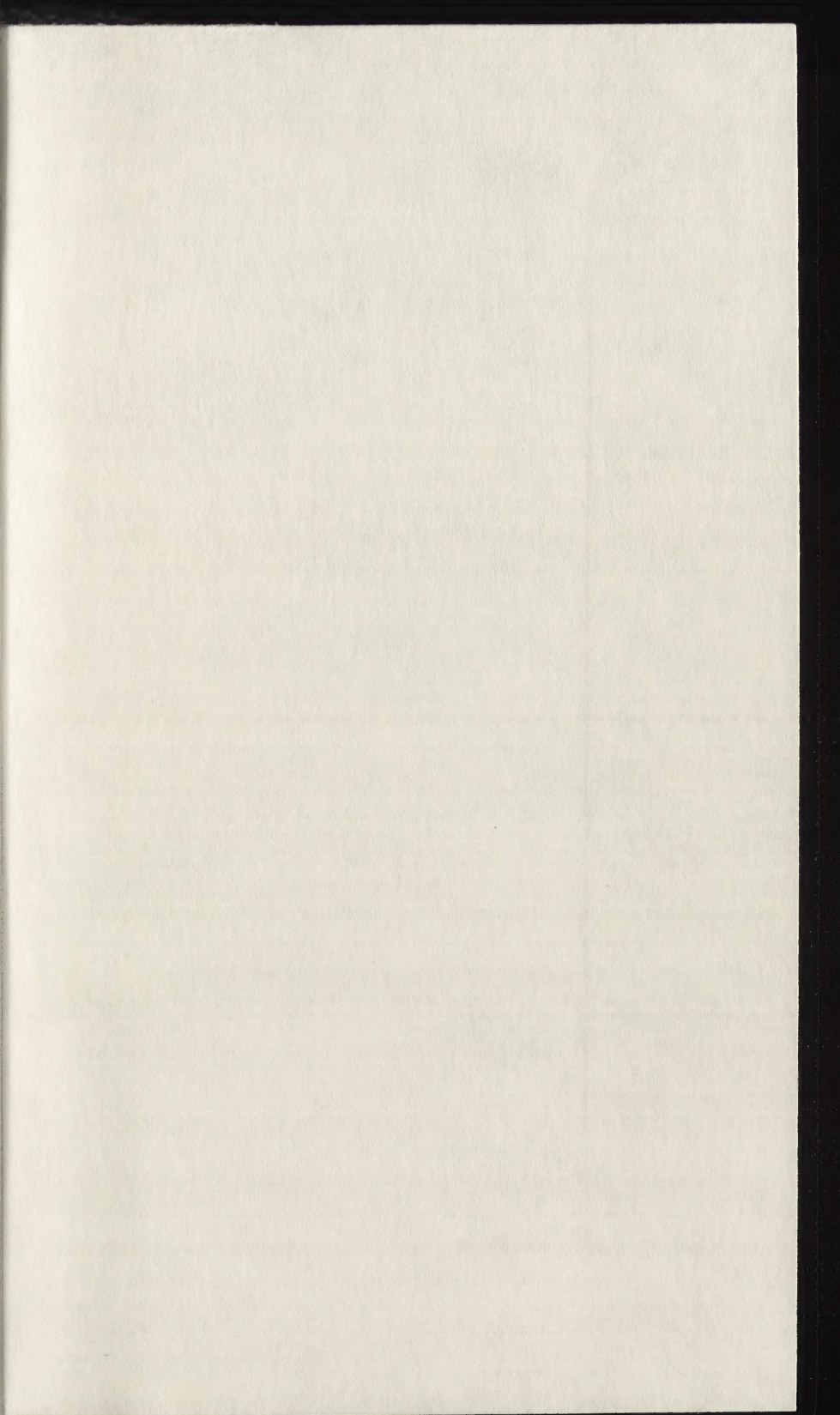


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